A FRACTAL-BASED MODEL TO IMPROVE COOPERATION AMONG PHYSICIANS IN DISTRIBUTED HEALTHCARE INFORMATION SYSTEMS

NAWZAT S. AHMED

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Name of Candidate: **Nawzat S. Ahmed** (I.C./ Passport: **G2023055**)

Registration metric number: **WHA080031**

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ABSTRACT

The system cooperation has become an important issue and used in healthcare systems to exchange information and ideas among physicians. Healthcare systems generally have distributed structures and consist of individual centres supported by autonomous Healthcare Information Systems (HISs). HISs serve as bases for exchanging healthcare information among physicians within the hospital environment. In the available literature, many studies have developed cooperative HISs models to improve cooperation among physicians in sharing patient information, as depositories to provide better services. However, none of these studies focused on the development of cooperative HISs models to improve physician skills to provide quality care to patients. In most developing countries, such as Iraq, cooperation among physicians in sharing information and skills in the patient treatment within the hospital environment is still very poor. Such poor cooperation can lead to insufficient outcomes where lack of medical skills yield disastrous consequences. In this study, a fractal approach has been used in proposing the Fractal-based Healthcare Information System (FHIS) model to improve cooperation among physicians in sharing information and skills within same and between different hospitals. The data collection has been carried out at two government hospitals in Kurdistan region of Iraq, as a case study. The mixed method approach, which combines questionnaires and semi-structured interviews, conducted, (1) to determine the current levels of cooperation among physicians with regard to sharing information and skills in the patient treatment, within selected Iraqi hospitals, (2) to determine factors that affect such cooperation among physicians, (3) to determine how the activities of Research and Development (R&D) units affect cooperation among physicians, and (4) to develop a FHIS model intended to improve cooperation among physicians with regard to the sharing of information and skills. Questionnaires were distributed among one hundred physicians; however, only eighty one questionnaires were completed and considered for analysis. Ten specialist physicians were selected for semi-structured interviews. Results showed an availability lack of cooperation among physicians. This lack of cooperation occurred because of significant factors, such as system units wish to maintain autonomy; a flexible cooperative approach is not the norm in the developing of cooperative HISs; large amounts of data are difficult to manage and control in manual and centralized systems; new knowledge is not acquired in a timely manner; physicians work independently; and R&D unit activities are weak. This study also concluded that a positive relation exists between R&D unit activities and cooperation among physicians using a simple regression analysis ($F(1,79)=7.230$). The FHIS has been implemented in participating hospitals to evaluate the system usability and the effect of this system in improving cooperation among physicians. The mixed method of questionnaires and semi-structured interviews were conducted in the evaluation process. Results indicated that the FHIS is satisfactorily (system usability scale scores = 75.04) and the cooperation among physicians in sharing healthcare information corresponds to significant improvements in skill using a paired samples T test ($t(55)=-20.486$). Further research needs to consider the cooperation between administrative and financial sections as well as the data-viewing privacy of physicians.

ABSTRAK

Sistem koperasi telah menjadi satu isu yang penting dan digunakan di dalam sistem penjagaan kesihatan untuk pertukaran maklumat dan idea di kalangan para doktor. Sistem penjagaan kesihatan amnya mempunyai struktur teragih dan terdiri daripada pusat tersendiri yang disokong secara autonomi oleh Sistem Maklumat Kesihatan (SMK). SMK merupakan asas bagi pertukaran maklumat penjagaan kesihatan di kalangan pakar-pakar perubatan dalam persekitaran hospital. Dalam dapatan literatur, banyak kajian telah membangunkan model koperasi SKM untuk meningkatkan kerjasama di kalangan pakar-pakar perubatan dalam berkongsi maklumat pesakit sebagai rizab untuk menyediakan perkhidmatan yang lebih baik. Walau bagaimanapun, tiada kajian yang tertumpu kepada pembangunan model SMK koperasi untuk meningkatkan kemahiran doktor di dalam menyediakan rawatan yang berkualiti kepada pesakit. Di kebanyakan negara membangun seperti Iraq, kerjasama di kalangan doktor dalam perkongsian maklumat dan kemahiran untuk rawatan pesakit dalam persekitaran hospital masih sedikit. Kurangnya kerjasama menjurus kepada hasil yang tidak begitu memuaskan di mana kekurangan dari segi kemahiran perubatan boleh mengakibatkan kesan buruk. Dalam kajian ini, pendekatan fraktal telah digunakan dalam mencadangkan model Sistem Maklumat Kesihatan berasaskan Fraktal bagi meningkatkan kerjasama di kalangan pakar-pakar perubatan dalam perkongsian maklumat dan kemahiran sama ada dalam hospital yang sama dan di antara hospital yang berbeza. Kajian kes melibatkan pengumpulan data yang dilaksanakan di dua buah hospital kerajaan di daerah Kurdistan, Iraq. Kaedah kajin secara gabungan iaitu soal selidik dan temu bual separa berstruktur telah digunakan (1) untuk menentukan tahap kerjasama semasa di antara doktor berkaitan perkongsian maklumat dan kemahiran dalam merawat pesakit di hospital terpilih di Iraq, (2) untuk menentukan faktor-faktor yang mempengaruhi kerjasama di kalangan doktor, (3) untuk menentukan bagaimana aktiviti unit penyelidikan dan pembangunan mempengaruhi kerjasama di kalangan pakar perubatan, dan (4) untuk membangunkan model Sistem Maklumat Kesihatan berasaskan Fraktal yang bertujuan untuk meningkatkan kerjasama di kalangan pakar-pakar perubatan dalam perkongsian maklumat dan kemahiran. Soal selidik telah diedarkan kepada 100 orang doktor namun hanya 81 soal selidik sahaja yang lengkap dan dipertimbangkan untuk analisis. Seramai sepuluh orang doktor pakar telah dipilih untuk temuduga separa berstruktur. Keputusan menunjukkan kurangnya kerjasama di kalangan pakar-pakar perubatan. Ini berlaku kerana faktor-faktor utama seperti sistem unit ingin terus mengekalkan autonomi; pendekatan koperasi yang fleksibel adalah bukan kebiasaan dalam membangun SMK koperasi; jumlah data yang besar sukar untuk diurus dan dikawal dalam sistem manual dan berpusat; pengetahuan terkini tidak diperoleh pada masa yang tepat; para doktor bekerja secara bebas dan aktiviti unit penyelidikan dan pembangunan adalah lemah. Dengan menggunakan analisis regresi mudah, kajian ini juga menyimpulkan bahawa wujud hubungan positif antara aktiviti unit penyelidikan dan pembangunan dan kerjasama di kalangan pakar-pakar perubatan (F (1,79)=7.230). Sistem Maklumat Kesihatan berasaskan Fraktal telah dilaksanakan di hospital terpilih untuk menilai kebolehgunaan sistem dan kesan sistem ini dalam meningkatkan kerjasama di kalangan pakar-pakar perubatan. Kaedah gabungan soal selidik dan temu bual separa berstruktur telah dijalankan dalam proses penilaian. Keputusan menunjukkan bahawa Sistem Maklumat Kesihatan berasaskan Fraktal adalah memuaskan (skor sistem skala kebolehgunaan=75.04) dan penilaian menggunakan sampel berpasangan ujian T menunjukkan kerjasama di kalangan pakar perubatan dalam perkongsian maklumat penjagaan kesihatan berkadaran dengan peningkatan yang ketara dalam kemahiran (t (55)= -20.486). Penyelidikan lanjut diperlukan untuk melihat kerjasama antara bahagian pentadbiran dan kewangan serta privasi di dalam paparan maklumat untuk para doktor.

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INTRODUCTION

1.1 Background of the Research

Information system (IS) applications have become an important part in many fields that provide daily operation of information (Bartosek, Staudek, & Wiedermann, 1995; Stair & Reynolds, 2010). These systems can consist of independent units working as a cooperative distributed system (Masaud-Wahaishi & Ghenniwa, 2009). As an IS, each unit has the autonomy to process activities, but can also work with other units to achieve system goals (Asnina, Osis, & Kirikova, 2008).

In the field of healthcare, organizations include individual centres supported by autonomous healthcare information systems (HISs), such as hospitals (Fedele, 1995). HISs were first presented in hospitals three decades ago to help medical staff with their job (Yang, Sun, & Lai, 2009). HISs in hospitals collect and store electronic information, such as patient records, doctor schedules, and others (Al-khawlani, 2009). These HISs have been adapted to suit different departments and services of healthcare organizations, such as hospital information systems, radiology information systems (RIS), laboratory information systems(LIS), picture archiving and communication systems (PACS), and so on (Li & Yao, 2006). HISs play an important role in providing patient information to physicians, nurses, and administrative staff, thus HISs can be a significant factor in developing cooperation among physicians with regard to sharing healthcare information (Gaboury, Bujold, Boon, & Moher, 2009; Reddy, Gorman, & Bardram, 2011; Yang, Liu, & Li, 2010; Yang, Sun, et al., 2009).

Although healthcare systems are considered as complex (Kannampallil, Schauer, Cohen, & Patel, 2011), the medical tasks of the components of these systems should essentially be cooperative activities to enhance healthcare services (Reddy, et al., 2011; VanVactor, 2011). However, in many developing countries, HISs are separate from each other and mostly use manual systems. Such situation is evident in most Iraqi hospitals (Ali, Abdulsalam, & Hasan, 2011). Disintegrated HISs and manual systems result in lack of information sharing and cooperation among medical staff (Braa & Humberto, 2007; Chiasson, Reddy, Kaplan, & Davidson, 2007; Dembo, 2010). In such cases, distributing information among medical staff, especially physicians, within the hospital is difficult. Such data are important in supporting decisions of physicians, enhancing their knowledge and skills, and improving healthcare services (Dembo, 2010; Kannampallil, et al., 2011; Mun, Shin, Lee, & Jung, 2009).

Given the aforementioned situation, cooperation (that is, sharing of information) in the field of healthcare environment is complicated process (Gaboury, et al., 2009). Several researchers call such exchange of information as "collaboration". In this study, the term "cooperation" is used. VanVactor (2011) defined cooperation in the healthcare field as a "synergistic work environment wherein multiple parties must work together toward the enhancement of healthcare management practices and process." Such cooperation can improve patient treatment and provide physicians with up-to-date information which can help them make informed decisions (Ruxwana, Herselman, & Conradie, 2010). Hence, the need for an integrated multi-HIS to ensure a cooperative healthcare environment is urgent (Yang, Liu, et al., 2010). Such joint undertakings also promote camaraderie among medical staff (Weir et al., 2011). However, new requirements will emerge over time in such cooperative HIS environment (Reddy & Spence, 2008; Skilton, Gray, Allam, & Morrey, 2007). These requirements need to maximize information sharing among practitioners, such as physicians, to provide useful information in an appropriate and timely manner to support decisions of physicians and enhance healthcare services. Such cooperation among physicians has become an important consideration in overcoming many recent challenges (Skilton, et al., 2007), such as: 1) the management and control of huge data in complex healthcare systems, 2) maintaining autonomy of each site, 3) a flexible cooperative approach in view of the dynamic nature of healthcare services, and 4) real-time acquisition of new knowledge from external sources to form a multi-expert care team (Dembo, 2010; Skilton, et al., 2007; Skilton, Gray, Allam, Morry, & Bailey, 2008). Therefore, cooperative HISs require flexible units that work together to represent subsystems. For example, hospitals can rapidly change and exchange productive information based on their own requirements. The importance of cooperation among system units lies in system goals themselves (Xiao, Hu, Croitoru, Lewis, & Dasmahapatra, 2010).

Dembo (2010) reported that through HISs, sharing of information (such as new diagnostic and therapeutic techniques) among clinicians can expand their referral network and improve their knowledge. Unfortunately, current manual systems used for keeping healthcare information and patient records make managing and distributing patient information among physicians within the hospital difficult. Also, given the diversity of patient-care teams (general practitioners, specialists, pharmacists, and community care nurses, among others) and their busy schedules, healthcare professionals do not have time to communicate and share knowledge among themselves. Therefore, information technology (IT) plays an important role in promoting cooperation among healthcare professionals through sharing of information in a timely manner, thus leading to quality care for patients (Reddy & Jansen, 2008). In addition, distribution of patient information among doctors in the same hospital and in other hospitals is another form of cooperation which can help doctors, particularly when knowledge of a patient's disease is lacking or incomplete (Huang, Jennings, & Fox, 1995).

Skilton, Gray, Allam, and Morrey (2007) mentioned that the move toward developing cooperative HIS approaches to established collaboration among healthcare practitioners in sharing patient information presents several challenges such as those mentioned earlier. Therefore, establishing cooperative HIS approaches to support collaboration among healthcare practitioners requires access of practitioners to appropriate, flexible, and comprehensive patient information based on their requirements (Skilton, et al., 2008).

Moreover, Yang, Qin, Jiang, and Liu (2008) reported that improvements in medical treatments and research on the field of healthcare is related to having an automated system that aggregate healthcare information in an integrated database. Such a system can stimulate more interdisciplinary research studies. For example, previous researchers developed the Medical IS for Chronic Viral Hepatitis (MISCHV) to aggregate information related to this chronic illness in a centralized database using Web-based applications. Such information can be used by healthcare practitioners to improve their understanding of chronic viral hepatitis.

A number of cooperative HIS models have been proposed to connect multi-HISs. These models have been developed as depositories of patient information among system units (such as medical staff) to concentrate on a patient’s problem and provide effective care (Aknine & Aknine, 1999). However, most of these models focus only on the disease that contains patient data within a limited range of functions (Weir, et al., 2011). For example, the electronic medical record system has been developed as a depository of patient information distributed among medical staff to provide individual healthcare services to patients (Reddy, et al., 2011).

Reddy and Jansen (2008) noted that medical staff in healthcare organizations conduct most of their work in a cooperative setting; however, information behaviour is still individualistic and not cooperative. Also, previous researchers explained that the design model of healthcare information focuses on the conventional model of interaction between a healthcare practitioner and technology which is individual and not cooperative. In a cooperative HIS environment, caregiving teams need to work together in seeking and sharing healthcare information to make appropriate patient-care decisions and to improve their services.

Yang, Liu, and Li (2010) argued that the improvement of patient treatment level in hospitals depends on the efficient management and use of computerized medical ISs. However, most of these systems are still isolated from each other, lack interoperability, and are unable to share information, thus leading to decreases in the use of human resources in the hospital. Previous researchers also noted that an integrated large-scale HIS, which includes many interoperable subsystems, should be able to adapt to the changing requirements of healthcare practitioners.

Chiu, Chan, and Chang (2007) proposed a National Immunization IS (NIIS) central database to aggregate data from different databases at different locations. Such a model aims to reduce the time needed to obtain patient information because data will be acquired from only one source instead of from different sites, thus allowing practitioners to provide care more quickly.

Chiasson, Reddy, Kaplan and Davidson (2007) mentioned that systems that support and enhance cooperation among healthcare professionals are essential to patient outcomes. Poor cooperation among medical staff, resulting from insufficient HIS design for managing and controlling staff practices, leads to unfavourable patient outcomes. For instance, the same authors claimed that 2500 Canadians and 95,000 Americans die each year because of poor cooperation among medical staff.

According to the World Health Organization (WHO) and the Ministry of Health (MOH) of Iraq, the lack of computerized HIS in most Iraqi hospitals leads to poor data analysis and information flow within the hospital environment. Also, the healthcare system in Iraq is still centralized and hospital-based. This situation happened because the country faced enormous problems, such as poor security and the effects of war. In Iraqi hospitals, physicians work individually and not cooperatively as a result of time factor. Most physicians work for three hours (9:00 to 12:00) during which they see between 30 and 100 patients. As such, the consultation time for each patient is between two to five minutes. Physicians also generally lack cooperation in sharing patient information and skills in their hospital and with other hospitals. These situations lead to inadequate access to primary care, low quality medical treatment level, and physical facilities that require major repairs (Alwan, 2004; World Health Organization, 2006).

Burnham et al. (2012) studied the effect of conflict on healthcare services in Iraq based on interviews with 401 Iraqi refugee doctors in Jordan. The aforementioned researchers found that after the 2003 invasion on Iraq, many doctors left the country because of the deterioration of healthcare services, shortage of medical staff, and violence against doctors (including several assassinations). Not surprisingly, current medical skills in Iraqi hospitals are very poor. The same researchers also mentioned that replacing lost human capital is the greatest challenge for the healthcare sector in Iraq.

In the Kurdistan Region, the regional minister of health reported that “the new generation is born with many diseases including congenital heart disease which we don’t know why and it may be associated with the long-term effects of chemical bombings in Kurdistan between 1987 and 1991” (Isa, 2008). The minister also said that heart disease is a major problem in the Kurdistan Region (Kurdistan Regional Government, 2007). However, skills and experiences of local surgeons and cardiologists are lacking (Custer, 2009).

In addition, the research and development (R&D) unit plays an important role in improving cooperation among staff and in enhancing services. Also, this unit can arrange an exchange or switch of operational activities among staff within the same and from different units (Chiesa, 1996). A number of hospitals hold regular weekly meetings for healthcare practitioners to discuss difficult cases of patients and design appropriate treatment plans. The goal of these meeting is the exchange of information and skills among physicians in the hospital. However, because of time constraints, several physicians cannot attend these regular meeting, thus they lose the opportunity to share their knowledge and skills with other physicians (Kuziemsky & Varpio, 2011). Furthermore, in most hospitals, physicians and nurses often cooperate through planned and unplanned verbal exchange of patient information. However, such verbal communication may lead to interruptions, errors caused by negligence, and information loss (Collins, Bakken, Vawdrey, Coiera, & Currie, 2011).

Several cooperative HISs that have been developed actually fail in supporting healthcare professionals in their work, especially with regard to their need for information in a cooperative environment (Scandurra, Hägglund, & Koch, 2008). Recent studies also show that in a cooperative HIS environment, information behaviour is still commonly perceived individually and not cooperatively (Reddy & Jansen, 2008). Most current HISs are still isolated from each other and do not permit sharing of information (Yang, Liu, et al., 2010). The reason is that approaches on cooperative HISs still focus on individual healthcare professionals, and model their decision-making processes (Scandurra, et al., 2008). Such approaches are unable to adapt to user requirements and system changes because each unit in HISs wishes to remain autonomous or independent (Skilton, et al., 2007). Thus, a flexible cooperative approach is important in improving physician skills through the acquisition of new knowledge within the hospital in a timely manner (Yang, Liu, et al., 2010; Yang, Sun, et al., 2009).

Therefore, the fractal approach (Warnecke, 1993) has been used by many researchers in different areas to develop a flexible and cooperative system (Kirikova, 2008; Tharumarajah, Wells, & Nemes, 1998). This approach, which is based on fractal theory and its features, intends to develop an integrated fractal-based IS (Kirikova, 2008; Ryu, 2003; Warnecke, 1993). According to Mandelbrot (Feder, 1988): “A fractal is a shape made of parts similar to the whole in some way.” A fractal-based system is an open and distributed system (Leitão & Restivo, 1999; Warnecke, 1993). The units of such systems have higher autonomy and more flexibility compared with other distributed system models (Kadar, 2001). Furthermore, in information communication technology, the fractal-based IS is developed based on multi-agent techniques (Ryu, Son, & Jung, 2003b). The fractal approach is used to solve the problem of lack of flexibility of systems in reacting to internal and external system requirements (Leitão & Restivo, 1999), as well as to achieve cooperation among system units (Xu, Zhao, & Yao, 2008).

This research, however, is primarily concerned on cooperation among physicians in sharing information and skills with regard to patient treatment within the same hospital and with external hospitals in the Kurdistan region of Iraq. It aims to improve such cooperation among physicians in order to improve their skills and enhance healthcare services. This aim can be achieved by developing a flexible and integrated cooperative HISs that supports sharing of appropriate and relevant healthcare information based on the requirements of physicians (Skilton, et al., 2008). HISs should use Web-based applications for sharing healthcare information among practitioners, especially physicians, working at different healthcare centres to improve knowledge in patient treatment and enhance research work in the field (Skilton, et al., 2007; Yang, Qin, et al., 2008). Given the important role of R&D units in improving cooperation among staff and in enhancing services, the fractal-based HIS (FHIS) model is proposed to develop a flexible and integrated cooperative system. Such a model involves similar units, as

R&D units, connected with different hospitals. The main purpose of the proposed model is to improve cooperation among physicians as mentioned previously. Therefore, the FHIS model is important to Iraqi hospitals, especially in the Kurdistan Region, to improve cooperation among doctors with regard to sharing of information and skills in patient treatment. This system will improve the skills of a small number of doctors and enhance research studies to provide better healthcare services to patients.

1.2 Problem Statement

Computerized healthcare systems in hospitals play an important role in providing and sharing healthcare information among medical staff, especially physicians (Yang, Liu, et al., 2010; Yang, Sun, et al., 2009). However, most models of cooperative HISs only allow sharing of patient information among medical staff to concentrate on the problems of a particular patient and provide effective care (Chiasson, et al., 2007; Reddy & Spence, 2008). In addition, these models focus only on diseases that contain patient data within a limited range of functions. As such, these models of cooperative HISs fail to improve physician skills or enhance healthcare services (Dembo, 2010; Skilton, et al., 2007; Skilton, et al., 2008). Generally, sharing healthcare information among practitioners at different locations is rarely handled by existing cooperative HISs. This situation leads to delay in the exchange of information and knowledge among healthcare practitioners which does not help strengthen cooperation among them within different hospitals (Skilton, et al., 2008).

The cooperation among physicians in sharing information and skills in the patient treatment within the hospital environment in many developing countries including Iraq is very weak (Reddy, et al., 2011; Ali, et al., 2011). This weak occurs due to HISs that are still separated from each other (Yang, Liu, et al., 2010) and mostly use manual systems (Ali, et al., 2011; Mengiste, 2010). Disintegrated HISs and manual systems hinder information sharing and cooperation among medical staff, thus impeding optimal use of healthcare resources and delaying applications of new diagnostic and therapeutic techniques because large amounts of data are difficult to manage and control in a system that uses paper. In such cases, distributing information regarding new discoveries among hospitals is difficult. However, these new information are important in enhancing physicians' knowledge and skills, and improving healthcare services (Dembo, 2010; Mengiste, 2010). Several studies (Chiasson, et al., 2007; Dembo, 2010; Kannampallil, et al., 2011; Masseroli, Visconti, Giovanni Bano, & Pinciroli, 2006) introduced another important factor that affects cooperation among physicians, that is, new knowledge is not acquired in real-time in disintegrated HISs and manual systems. Yet another significant factor occurs when physicians work individually in treating patients. This practice does not improve physician skills in diagnosing patients and can lead to insufficient experience (Burnham, et al., 2012; Mun, et al., 2009; Weir, et al., 2011). The aforementioned factors critically affect cooperation among physicians, which can lead to poor patient outcomes (Reddy, et al., 2011).The bigger challenge is strengthening sharing of healthcare information and skills among different hospitals, many of which still rely on paper-based records, especially in Iraq (Ali, et al., 2011; World Health Organization, 2006). As such, introducing new activities to hospitals is a difficult process. These activities are important in enhancing healthcare services. Caregivers, particularly physicians, within the same hospital or from different hospitals, need to cooperate and communicate with each other to provide safer and more accessible care to patients and to improve their skills. The need to address such cooperation among physicians is of utmost importance, now more than ever.

1.3 Objectives of the Research

This study aims to:

1. determine the current levels of cooperation among physicians with regard to sharing information and skills in the patient treatment, within selected Iraqi hospitals;
2. determine factors that affect cooperation among physicians with regard to sharing information and skills, within the hospital environment;
3. determine how the activities of R&D units affect cooperation among physicians; and
4. develop a FHIS model intended to improve cooperation among physicians with regard to the sharing of information and skills.

1.4 Questions of the Research

Based on the objectives listed in Section 1.3, the following research questions have been formulated:

1. What are the current levels of professional cooperation among physicians in selected Iraqi hospitals with regard to the exchange of knowledge and experiences? (Objective 1)
2. What are the significant factors that influence levels of cooperation among physicians with regard to sharing information and skills in the hospital environment? (Objective 2)
3. How do R&D units affect cooperation among physicians within the hospital environment? (Objective 3)
4. What system requirements should be in FHIS model? (Objective 4)

5. To what extent does the FHIS model improve cooperation among physicians with regard to sharing information and skills? (Objective 4)

1.5 Scope of the Research

This research aimed to determine current levels of professional cooperation among physicians in sharing healthcare information within the hospital environment. It also examined significant factors affecting such cooperation. Furthermore, this research proposed an integrated cooperative HIS model to improve cooperation among physicians with regard to sharing information and skills within the same hospital and with other hospitals.

a) Given the diverse means of cooperation among medical staff, especially among physicians, this research focused only on cooperation among physicians in sharing information and skills in patient treatment within the same hospital and with other hospitals.
b) This research only covered selected government hospitals, and not private ones, because of the difficulty of establishing connections and distributing healthcare information between government and private hospitals.
c) This research was restricted to selected cardiac centres of government hospitals because of the difficulty in studying the entire healthcare system of hospitals. Each hospital has multi-units, such as cardiology (cardiac centre), accident and emergency unit, diagnostic imaging unit, and so on. Each unit has an IS that manages and controls the work of the unit and that cooperates with other units, to achieve system goals. Therefore, in hospitals with a large number of units, connections between ISs are very complex and need more time to be established (Al-khawlani, 2009; Kannampallil, et al., 2011; Masaud-Wahaishi & Ghenniwa, 2009; Yang, Liu, & Gan, 2009).

d) Hospitals that do not have a cardiology unit were not included in this research.

e) Selected hospitals were also considered as teaching hospitals to address the R&D unit activities within the hospital environment.

f) This research proposed an FHIS model for cardiac centres of government hospitals in the Kurdistan Region of Iraq for the following reasons: 1) the increasing number of heart-disease cases among young people in the region, and 2) the small number of cardiac centres, local cardiologists, and cardiac surgeons in the region.

The primary participants in this research were physicians working in units related to cardiac centres in hospitals. A total of 100 physicians from two government hospitals in the Kurdistan Region took part in this study. They included hospital managers, doctors, senior house officers, intervention cardiologists, and cardiac surgeons.

1.6 Limitations of the Research

The research focused only on the cooperation among physicians with regard to the sharing of information and their skills in patient treatment within the same hospital and with other hospitals. Other types of cooperation among medical staff, such as chat and video conference, were not considered in this research. The implication of this study is that sharing healthcare information among physicians in asynchronous ways probably has greater potential to improve cooperation among them and enhance their skills.

The Kurdistan Region in Iraq was chosen because this region is experiencing rapid development in health facilities, and the place is relatively safe compared with other areas in the country. The selected hospitals are the only two hospitals in the Kurdistan region of Iraq (research focus area) that have cardiac centres and expert physicians.

The privacy and security of data communication for the proposed model in this research were subject to authentication and authorization. The confidentiality of information controlled by R&D units of such a model was ensured.

1.7 Motivation of the Research

The main motivation of this research was to develop integrated cooperative HISs among Iraqi government hospitals to improve cooperation among physicians with regard to sharing information and skills in patient treatment.

Second, after the 2003 invasion of Iraq, many doctors left the country, resulting in the deterioration of healthcare services. The healthcare system based on manual operations in most Iraqi hospitals (Ali, et al., 2011; Burnham, et al., 2012) did not help alleviate the situation. Thus, the Ministry of Health (MOH) of Iraq has launched a program to improve the healthcare systems in the country by developing a high-quality computerized HISs (Evans, 2004). The first phase of HIS improvement has began within the MOH itself, and the system is still in its early stage of development (Cressman, 2005). Other programs are ongoing, such as the Iraq Health Enterprise Planning and the Disease Surveillance System, which are part of the national HIS based on international standards (Evans, 2004; Koudry, 2004). Furthermore, the Country Cooperation Strategy of 2005–2010, a joint project of the WHO and the Iraqi government recommended that the HIS in the country needs to be strengthened. In particular, the Federal Region of Kurdistan in Iraq recently moved to automate the healthcare systems of regional healthcare organizations, with the support of the Regional Ministry of Health (Heshmati & Darwesh, 2007).

Third, the increasing incidence of heart diseases among young people in the Kurdistan Region (Alshekhly, 2006) and the recent establishment of a few cardiac centres in this region also motivated this research. Thus, physicians at these centres need to cooperate with each other to improve their skills and enhance their ability to provide excellent medical services to citizens (Kurdistan Regional Government, 2007).

Finally, this research identified significant factors affecting cooperation among physicians with regard to the aforementioned reasons. It would cover physician requirements to develop an effective cooperative HIS environment for data collection which could be used to improve skills of physicians and enhance research studies within the hospital environment.

1.8 Significance of the Research

Computerized healthcare systems in hospitals are important in enhancing cooperation among physicians through the exchange of healthcare information among different hospitals. An extensive literature review found no studies on the development of a cooperative HIS environment to improve physician skills within the same hospital and in other hospitals, especially in Iraq. Therefore, through this study, the following effects would be achieved:

1. More autonomy for each healthcare centre in the proposed FHIS model in selecting objectives and functions, and in cooperating with other units.
2. Enhanced healthcare services by updating and distributing information among physicians to select the best solutions for patient treatment.
3. Quick response to queries among physicians to address the difficulty of diagnosing or treating certain cases.
4. Collecting information from independent counterpart units (that is, R&D units) of hospitals to obtain more integrated knowledge and to maximize information flow among system units.
5. Creating an integrated navigation system for researchers, that is, physicians searching for relevant information to improve operation of hospitals.

6. Improving physician skills and research work by sharing and distributing physician activities within the same hospital and with different hospitals.
7. Development of a more open and flexible cooperative HIS structure to quickly adapt to changes in the healthcare environment.

1.9 Organization of the Thesis

The earlier sections of this chapter explain the background of the study and introduce the use of HISs in hospitals to improve cooperation among physicians in sharing information and skills within the hospital environment. This section is followed by the statement of the problem, the main objectives, the research questions, the scope of research, the limitations, motivations, and significance of the study.

Chapter 2 examines the cooperation among physicians in sharing information and skills in patient treatment within the same hospital and with other hospitals. The chapter also explains factors affecting cooperation among physicians in sharing healthcare information. Chapter 2 also reviews studies on the developing cooperative HIS environment in general. Then, the chapter introduces the concept of the fractal approach, its features, and implementation in designing fractal-based IS in general and in developing a cooperative HIS environment in particular.

Chapter 3 discusses the research design, the instruments used, and the data collection methods. Then, it explains how the proposed system was implemented, tested, and evaluated.

Chapter 4 presents the details of the hospitals that participated in this research as case studies.

Chapter 5 presents the results of data analysis to address research questions and requirements of the physicians for the FHIS model.

Chapter 6 presents the design and implementation of the FHIS, such as a description of the development platform and the use of various modules. Afterwards, this chapter shows the evaluation process of the FHIS and its results.

Chapter 7 summarizes the entire research by looking back at what has been done to achieve the objectives of the study. It discusses the findings and gives recommendations on directions of future research. Finally, it provides the concluding remarks for the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The review of relevant literature helped the researcher determine the extent of research conducted with regard to the topic. Furthermore, the review exercise made it easier for the researcher to define the research problem. The review process also yielded new concepts and terms relevant to the study. Then, the review helped identify and discuss the theoretical framework used as the foundation for the development of a flexible and cooperative HIS environment to improve cooperation among medical staff, especially among physicians.

The chapter begins with a brief introduction to computerized healthcare systems in hospitals. This introduction is followed by: (1) a review of literature related to levels of cooperation among medical staff, especially physicians, with regard to sharing healthcare information within the hospital environment, (2) a review of the role of R&D units in enhancing cooperation within the hospital environment, (3) an overview and critical analysis of several models for the development of a cooperative HIS environment, and (4) a discussion of the fractal theory and its features. Then, this discussion is followed by a review of applications using the fractal approach to build flexible and cooperative models. The next section discusses the adaptation of fractal features in distributed HISs to propose a conceptual model of FHISs to address the research problem. Finally, the literature review is summarized in relation to the research questions and a proposed conceptual model for a cooperative HIS environment based on fractal theory is presented.

2.2 HISs in Hospitals

Healthcare organizations include individual healthcare centres, such as hospitals. Computerized healthcare systems in hospitals are supported by autonomous HISs (Fedele, 1995). HISs were first presented in hospitals three decades ago to help physicians, nurses, and administrative staff with the daily work (Yang, Sun, et al., 2009). HISs in hospitals include electronic information, such as inpatient and outpatient records, inpatient discharge data, laboratory data, primary care data, doctor schedule data, and others (Al-khawlani, 2009; Mäenpää, Suominen, Asikainen, Maass, & Rostila, 2009). These HISs are used in different departments of a hospital under different names and with different healthcare services provided (Li & Yao, 2006). Several examples of medical ISs in hospitals are hospital ISs, RIS, LIS, and PACS. These systems use effective processes to meet the needs of the departments in providing healthcare information for the medical staff (Li & Yao, 2006; Sadreddini, 2003). However, IS applications in healthcare require a combination of technological and social skills to reach a high level of HIS environment and provide quality care to patients. This combination is important in raising efficiency of the systems by automating activities in the hospital. Information technology is responsible for elevating the effectiveness of the system to help healthcare practitioners in patient care (Kohli & Hoadley, 2007). Samuel (2009) added that information communication technology (ICT) can be employed as a tool to communicate skills of members to improve the level of teaching and learning in the education system. Hence, HISs have positive effects on healthcare procedures and patient outcomes (Mäenpää, et al., 2009). As such, developed countries in Europe and the United States have directed their attention on computerized healthcare systems in their hospitals (Wickramasinghe, Bali, & Tatnall, 2007).

According to Ruxwana, Herselman, and Conradie (2010), the improvement of patient treatment, the management of healthcare system in hospitals, and the provision of up-to-date healthcare information to the medical staff can be done by using computerized healthcare systems. Researchers mentioned that information and communication technology applications, such as e-health, are suitable for providing healthcare information to improve the knowledge of medical staff. Hospitals use HISs to store healthcare information of patients related to disease management, including treatments. HISs in hospitals include patient information and treatment along with other medical systems, such as RIS and PACS, to provide integrated patient records used for diagnostic purposes (Sadreddini, 2003). The requirement of using e-health systems in hospitals have been improved to better store, distribute, and share healthcare information among medical staff within the healthcare environment (Masaud-Wahaishi & Ghenniwa, 2009).

Yang, Liu, and Gan (2009) argued that healthcare systems contain business collaborations within healthcare centres through systems similar to other business ISs. Although HISs are considered as complex, they are designed to effectively meet the needs and requests of the medical staff to provide an effective cooperative environment. Therefore, the analysis and modelling of such complex healthcare systems need to satisfy user requirements.

According to studies by Reddy and Spence (2008), Scandurra , Hägglund and Koch (2008), and Weir et al. (2011), healthcare practitioners need computerized healthcare systems to collaborate with other physicians and healthcare practitioners to improve their activities and patient outcomes. Although most people who work in the field of healthcare is cooperative, most HISs in hospitals are still insufficient to meet the cooperative dimensions of work and fail to support healthcare practitioners in their work. This situation happens because HIS developments were not focused on user requirements in the cooperative work process. The success of HISs lies in having users themselves involved in the development process.

HISs in hospitals play an important role in providing patient information to physicians, nurses, and administrative staff (Shahmoradi, Ahmadi, & Haghani, 2007). In addition, the connection of HISs among hospitals located in different regions can support collaborative work between remotely located doctors and centres through exchange of patient information (Maglogiannis & Zafiropoulos, 2006). Many regional HISs have been developed to allow quick and effective exchange of up-to-date patient information among practitioners in far-flung locations (Mäenpää, et al., 2009). Hence, distributed or regional HISs can be an important factor in developing cooperation among physicians within the healthcare system (Gaboury, et al., 2009; Reddy, et al., 2011; Yang, Liu, et al., 2010; Yang, Sun, et al., 2009). Therefore, the need for an integrated multi-HIS that can provide an effective HISs environment is urgent (Yang, Liu, et al., 2010).

Web-based applications have been used by many researchers to develop an effective cooperative HISs environment. Such applications can provide many benefits to healthcare systems. These applications can play an important role in connecting different HISs to exchange healthcare information among medical staff within the same and with other healthcare centres to provide quality care to patients. These applications can also support real-time cooperation among medical staff (Hameed et al., 2008).

Based on previous studies, cooperation in healthcare systems is important for improving physician skills as well as patient treatment and outcomes. The researchers in this study focus on the development of a flexible cooperative HISs environment to satisfy user requirements in the cooperative work process to share vital information within the hospital environment. This study focuses on identifying current levels of professional cooperation among physicians and their skills in patient care management.

2.3 Cooperation among Physicians within the Hospital Environment

The term "cooperation" in the field of health care is defined as the communication that occurs among healthcare practitioners when sharing information and skills in patient care (Gaboury, et al., 2009; Scandurra, et al., 2008; Weir, et al., 2011). Cooperation may also "involve two or more people engaged in interaction with each other, within a single episode or series of episodes, working toward common goals" (Patel, Pettitt, & Wilson, 2012). The literature review in this section covers a number of relevant issues on cooperation among physicians from different centres or hospitals. It aims to discover the levels of cooperation among physicians in sharing information and the effect of this cooperation in patient outcomes. As noted in various studies, the nature of medical work in healthcare systems is cooperation among healthcare professionals (Chiasson, et al., 2007; Kuziemsky & Varpio, 2011). Researchers have directed their attention to study the role of cooperation in health care and how to best support cooperation among the medical staff. Results show that poor technology systems may result in lack of cooperation among the medical staff (Reddy, et al., 2011), and consequently, may harm patients (Weir, et al., 2011). According to Reddy et al. (2011), an established cooperation among physicians and healthcare workers needs an appropriate communication system. In the field of health care, various types of communication and information exchange occur among medical staff to support cooperation. The general model of collaboration in any system is illustrated in Figure 2.1 (Abdullah, Selamat, Sahibudin, & Alias, 2005).

	Same Time	Different Time
Same Place	Face-to-face collaboration (Synchronous)	Asynchronous collaboration
Different Place	Distributed Synchronous Collaboration	Distributed Asynchronous Collaboration

Figure 2.1: Collaboration of working model (Abdullah, et al., 2005)

Figure 2.1 shows that four types of collaboration exist, including face-to-face collaboration, which is a type of synchronous collaboration. Verbal communication between physicians and nurses in hospitals is an example of such collaboration. Another type of collaboration is asynchronous collaboration, in which hospital staff use electronic health records (EHRs) as tools for communication (Collins, et al., 2011). E-mail and instant messaging are also useful means of communication in clinical settings to support asynchronous collaboration among medical staff (Kuziemsky & Varpio, 2011; Reddy & Jansen, 2008). Another type of collaboration is distributed synchronous collaboration, which uses video-conferencing and telemedicine systems (Hameed, et al., 2008). Finally, a distributed asynchronous collaboration is another type of collaboration wherein healthcare practitioners can cooperate with each other by sharing healthcare information and activities in different times and places. HIS is a type of asynchronous and distributed asynchronous collaboration. Such systems provide patient information to physicians, nurses, and administrative staff about their work (Yang, Sun, et al., 2009).

The healthcare system has used many types of cooperation among healthcare practitioners, and HISs in hospitals have developed to allow easy exchange of up-to-date patient information among medical staff in real-time. Many researchers found that HISs can be an important factor in improving cooperation among physicians in sharing healthcare information with other health workers within and outside their hospitals (Gaboury, et al., 2009; Mäenpää, et al., 2009; Reddy, et al., 2011; Yang, Liu, et al., 2010; Yang, Sun, et al., 2009). As such, literature review has focused on the use of HISs as a tool for effective cooperation among medical staff, especially among the physicians, to allow sharing of information and skills for improving patient care.

Kuziemsky and Varpio (2011) carried out a study to enhance a cooperative care delivery and develop a HIS design to support it. They determined that poor cooperation among medical staff happened because the design for HISs to support asynchronous cooperation among care providers was still lacking. The previous study also discovered that possessing a HIS that supports such cooperation is necessary. Therefore, the aforementioned researchers proposed a model to enhance such cooperation and provide a basis for HIS design to support asynchronous cooperation within the hospital.

Li and Yao (2006), and Yang, Liu, and Li (2010) explained that integrated HISs in hospitals can improve the level of medical treatment, provide quality care to patients, and allow specialists to cooperate with each other across distances. The same researchers also said that current HISs in hospitals are isolated from each other and are usually designed to serve individual departments within the hospital. The lack of shared information among medical staff resulted in poor cooperation among specialists in hospitals.

According to Mengiste (2010), international healthcare organizations have directed their attention to strengthening the use of HISs in hospitals instead of paper-based systems. HISs can make data collection, analysis, and reporting more effective than manual systems. Also, Schabetsberger et al. (2006) mentioned that replacing manual systems with computerized systems in hospitals can improve cooperation among medical staff with regard to sharing patient information. Furthermore, Mengiste (2010) added that transforming existing manual systems into computerized systems is a difficult process often accompanied by several challenges and problems, which include lack of sufficient resources and inadequate knowledge on information technologies by the local medical staff. Therefore, this process needed flexible strategies to develop computerized healthcare systems.

Weir et al. (2011) explored the effect of computerized patient documentation (CPD) on clinical cooperation. They found out that the implementation of CPD was based on theories of communication among the medical staff. Also, CPD has the potential to improve communication and cooperation through the sharing of information. The same authors said that a good cooperation feature depends on theories of communication among medical staff to guide the design of integrated cooperative HISs.

According to studies by Ali, Abdulsalam, and Hasan (2011), Gaboury, Bujold, Boon, and Moher (2009), Hameed et al. (2008), Mengiste (2010), Scandurra et al. (2008), VanVactor (2011), and Yang, Liu, et al. (2010), many developing countries still use manual and stand-alone systems in their hospitals. These studies also indicate that using manual and individual systems has led to insufficient cooperation among medical staff. Furthermore, many hospitals nowadays use both manual and computerized systems because of the complexity of healthcare system environments (Kumar, Rao, & Govardhan, 2012).

Hameed et al. (2008) described how healthcare systems in Malaysia, a developing country in Asia, use manual and stand-alone systems because many of these systems don’t have real-time and mobile technologies. This situation also leads to failure in collaboration among medical staff. As such, the same researchers proposed the integrated Emergency, Health care, and Medical IS to overcome the aforementioned problem. This system was developed to help healthcare professionals obtain complete patient information from different devices or locations within the hospital.

Mengiste (2010) carried out a study to explore the challenges of transforming paper-based systems into computerized systems in Ethiopia, another developing country. Many healthcare systems in this country still use manual systems. The study also showed that implementing HISs in Ethiopia is difficult because the country faces socio-technical challenges in adapting and implementing such systems. Ethiopia does not have adequate resources (such as infrastructure and the fragmented nature of healthcare systems) and knowledge on information technology. Finally, Mengiste's study recommended considering socio-technical issues and factors that affect the process of adapting and implementing HISs in different healthcare settings, especially in developing countries.

Ali et al. (2011) reviewed and assessed HIS in war-stricken Iraq. Before 2003, Iraq was completely isolated from other countries around the world. After the 2003 invasion, healthcare services deteriorated and many doctors left Iraq. Public and private healthcare centres suffered and, consequently, so did effective cooperation within the healthcare systems. After 2004, the MOH of Iraq realized that information technology plays a significant role in healthcare systems to provide quality care to citizens. Thus, the MOH started using information technologies in healthcare systems. However, the MOH faced problems during the implementation of these techniques. The main reason for such difficulties was that healthcare systems in Iraq were hospital-based and centralized (World Health Organization, 2006). In addition, physicians were working individually and not cooperatively because doctor-to-patient ratio worsened after the war, thus leading to poor healthcare services (Alwan, 2004). The improvement of healthcare services within the hospital environment, medical staff attitudes towards giving them an adequate environment has to be measured to achieve the quality of healthcare (Al-Ta'e, 2009).

The studies in this section basically described cooperation among physicians with regard to sharing information and skills for effective health management within the hospital environment. Failure in effective cooperation results from many factors. Factors affecting such the cooperation among physicians explain as follows. First, many HISs were isolated from each other because of the fragmented nature of healthcare systems. Second, developing countries, such as Iraq, used paper-based processes in their healthcare systems. Third, healthcare systems in most developing countries were hospital-based and centralized. Fourth, physicians are forced to work independently because of the huge number of patients. Fifth, the socio-technical challenges faced by several health workers also play a role. Therefore, many developing countries need to introduce information technologies and effective cooperation in their healthcare systems (Mengiste, 2010). The management and control of activities, as well as the improvement of cooperation among the staff of an organization are among the goals of the R&D unit of such organization (Chiesa, 1996).

2.3.1 The Role of R&D Unit Activities in Hospitals

Generally, to improve the quality of any business, cooperation has to be established at the local and global levels among business units. According to Chiesa in (1996), cooperation among decentralized R&D units within the same firm has a positive effect on product outcomes. This effect is based on the fact that activities of R&D units in any setting play an important role in improving cooperation among staff and in enhancing services. In addition, Chiesa added that the tasks of R&D units can be carried out by exchanging activities among staff within the same and with different units. Furthermore, the acquisition of new knowledge by the staff can be investigated through externalization of R&D activities by exchanging information among the staff using Web-based techniques (Chiesa, Manzini, & Pizzurno, 2004).

According to an article in the Royal College of Nursing (2004), providing quality patient care depend on R&D activities in healthcare systems. This claim means that lack of collaborative activities may lead to poor patient outcomes. In addition, the improvement of practice, knowledge, and understanding of healthcare practitioners can be applied to R&D activities within the healthcare centre setting. Moreover, R&D activities in healthcare systems can improve medical systems and promote better medical care by using information and communication technologies (Kimura, Marvit, Fukuda, & Naseer, 2012).

Moreover, R&D activities have influenced the medical care level through supporting activities, such as research, development, facilitation, and cooperation. To support research, R&D activities have to provide information to a variety of groups and individuals, and manage the outcomes of studies. R&D units also have to develop new tools to assess and evaluate physician performance and to improve cooperation among hospital staff relative to their job (Medical Council of Canada, 2012). For instance, the role of the R&D unit in Morriston Hospital in Swansea, United Kingdom is to develop cooperation among researchers across the Swansea Region, especially among clinical academics in the College of Medicine at Swansea University. The goal of this unit is to manage data requests for new studies, to monitor research activities, and to exchange information on new studies among medical researchers (Abertawe Bro Morgannwg University Health Board, 2012, February 23). In addition, the R&D unit provides advice and support to enhance the quality of research and maintain a database of all clinical researchers (Oxford University Hospitals, 2011).

Furthermore, the R&D unit can manage and control the activities of the hospital, including physician performance in patient care. In several cases, regular weekly meetings are held among practitioners to discuss and share patient status and treatment. However, a number of physicians fail to attend such meetings, thus they lose the opportunity to share and learn new information (Kuziemsky & Varpio, 2011). Also, face-to-face communication occurs among caregiving teams, allowing cooperation for effective patient care. This face-to-face communication, however, can be affected by interruptions and loss of information (Collins, et al., 2011). In Iraqi hospitals, physicians are very busy because of limitations in working hours and the heavy work load. In such cases, physicians don't have the time to meet with each other or even attend regular meetings. This situation leads to lack of cooperation within the hospital (Alwan, 2004; World Health Organization, 2006).

This section has shown that R&D unit activities can manage and control hospital activities and help improve medical care and research work by sharing information among healthcare teams. Also, lack of activities of these units within the hospital leads to poor patient outcomes and inefficient research work. Therefore, information technology needs to play an important role in supporting effective cooperation among healthcare professionals to allow the sharing of information and skills relevant to patient care in a timely manner (Reddy & Jansen, 2008). Many cooperative HISs models have been developed by researchers to improve cooperation among medical staff, particularly in sharing healthcare information within the hospital environment.

2.4 Cooperative HIS Models

IS applications have become an important aspect in many fields (Bartosek, et al., 1995). These systems consist of independent units. Each unit, as an IS, has the autonomy to process activities but can also work cooperatively with other units (Asnina, et al., 2008).

As such, separate HIS units have to cooperate in a flexible manner (Yang, Liu, et al., 2009) to improve patient treatment and to provide up-to-date information, thus allowing physicians to make informed decisions (Ruxwana, et al., 2010). Although the nature of HIS units are decentralized and autonomous (Yang, Liu, et al., 2009), the need for an integrated multi-HIS that can provide an effective cooperative HIS environment is urgent (Yang, Liu, et al., 2010). However, traditional cooperative HISs have developed databases containing patient information to share among medical staff from different units (Skilton, et al., 2008).

The integration of HISs plays an important role in improving the levels of medical treatment in hospitals. Yang, Liu, Gan et al. (2009) presented the requirement driven adaptive architecture (RDAA) model to design an effective cooperative healthcare system in hospitals to meet user requirements. Even though healthcare systems are considered complex, the introduced model is capable of analyzing and modelling such systems. The RDAA model consists of "five layers including: requirement layer, service layer, process layer, function layer and data layer, five stanchion, technology and physical infrastructure." It proposes a guide which provides directions for designing an effective healthcare system. Therefore, Yang, Liu, and Li (2010) reported that an integrated HIS in hospitals connects medical ISs of various units from the aspect of software applications and management. This process is important in adapting to the developing medical environment. However, the previous authors reported that most HISs were isolated from each other and were mostly designed for a particular unit of medical care in a hospital. These systems also do not meet user requirement for the design of such systems. This situation led to lack of information sharing among healthcare practitioners. As such, the aforementioned authors stated that an integrated healthcare system based on well-established information architecture is the basis of IS structure modelling. The aforementioned authors presented the RDAA model for integrated healthcare systems in hospitals based on social and technical factors. This model was proposed to adapt to the complex and dynamic nature of the medical environment and to meet the requirements of practitioners to access integrated healthcare information in a hospital.

Sadreddini (2003) added that the integrated healthcare system architecture was presented not only for structuring patient records, but also multimedia data of a patient, such as PACS images. Hence, he introduced a framework of integrated distributed HIS in a hospital as a complete architecture to connect heterogeneous ISs, such as HIS and PACS, into an integrated system, which includes patient information and images. This framework was focused on integrating patient information within the hospital. According to Li and Yao (2006), the traditional development of HIS focused on stand-alone applications without integration. Although the nature of medical work is cooperation within the hospital setting, each hospital has multi-disintegrated heterogeneous ISs. Integrated heterogeneous ISs within, and between, hospitals can provide better care for the patient, support decisions of physicians, and improve cooperation and communication among the medical staff. Therefore, the previous researchers introduced framework architecture of cooperative work in integrated heterogeneous medical ISs within a hospital. This architecture suggested scenarios of cooperative work and included user interface layer, cooperation layer, information exchange layer, and common communication layer. This architecture of cooperative work was implemented as a simulation between HIS and LIS of medical ISs in a hospital based on Web applications. However, the proposed framework architecture of the previous research only addressed requirements needed in cooperative systems among multi-HISs. According to Yang, Sun, and Lai (2009), the integration of heterogeneous systems in a healthcare environment faces system scalability and interoperability, in terms of both hardware and software. Thus, the aforementioned researchers presented a new architecture for the integrated healthcare system in a hospital by studying scalability and interoperability of a system. The same researchers proposed service-oriented architecture-based HIS model by using service standard Health Level 7 (HL7) and Web-based services. By implementing such a model, the aforementioned researchers found that the model exhibited good performance in integrating patient information in a complex healthcare environment.

Skilton et al. (2007) mentioned that the nature of medical work correlates with patient care, and many cooperative caregiving teams work together at different locations. The same researchers also mentioned that the view of the caregiving team toward cooperative work involves new requirements, but the current systems do not support these requirements because of information challenges, such as the security and privacy of data relevant to patients, the diversity of data model to adapt to complex healthcare systems, the autonomy of each IS, the need for a flexible cooperative approach, and real-time access to healthcare information. To overcome these challenges, the previous researchers proposed a new approach called service-oriented virtual organizations (SOVO) to connect with HISs to provide medical staff with integrated patient information available at different sources. This approach was based on virtual organizations with service-oriented architecture. Local autonomy was supported by the local management database, and the view of complete patient information was provided through the virtual organization database. Because of security and privacy issues, the same researchers proposed the role-based approach in conjunction with the previous approach to access data relevant to a particular patient by a particular caregiving team in each location. The aim of this approach was to increase flexibility and extensibility of the system. However, this proposed model was still in its early stages and merely focuses on viewing patient information by individual caregiving teams in a centralized location acting as an individual virtual organization (Skilton, et al., 2008).

Huang, Jennings, and Fox (1994) stated that the aim of cooperative caregiving teams is to share information on providing effective care for a particular patient at distant locations. The same researchers also explained that this process needs a number of agents, such as humans and computer systems, to cooperate and achieve the common goal of keeping the patient healthy. Based on that assumption, the aforementioned researchers proposed the cooperative clinical IS to support previous requirements of the cooperative caregiving team. Such a system was developed based on social interaction among caregivers. The proposed system included general practitioners, specialists, nurses, and a computer system to exchange information regarding a particular patient. This information exchange was based on old communication processes performed by transferring messages among particular agents to accept or reject, and manage and control a particular patient. In 1995, the same researchers defined the agent as "an integrated entity involving a computer system and its user" (p.220). They also described the design and implementation of the agent architecture to support the cooperative caregiving team. The previous study addressed how to accelerate care for a particular patient by a group of caregivers (Huang, et al., 1995).

Aknine and Aknine (1999) proposed using a different model or agent in the hospital IS based on observations on interactions between the caregiving team and the patient. They suggested a multi-agent cooperation model called software agent model. This model allows hospital personnel (such as doctors, nurses, analysts, and others) to link data about a particular patient from different sources. It involves several similar agents. The main goal of this model is to support physicians by providing information related to the patient to accelerate the treatment process, especially in emergency situations. However, this model focuses only on patient information aggregated in a centralized location.

Physicians need a system to support their decisions. The centralized NIIS database refresh model was presented by Chiu, et al. (2007) to support decision-making processes of healthcare centres in Taiwan to control diseases. This model was based on an empirical data integration model and included a central database to investigate data aggregation from a number of databases of vaccination records available in different healthcare centres. This project can provide many benefits, such as providing vaccination information in an integrated format, supporting decision-making, and providing extensive data for analyzing healthcare professionals. The main disadvantage of this model is the lack of real-time updating of recent vaccination records. By contrast, Budgen, Rigby, Brereton, and Turner (2007) proposed the Integration Broker for Heterogeneous Information Sources (IBHIS) model instead of data integration in a central database. This model was used to help physicians make accurate diagnosis of cases by providing complete patient information from multi-database sources from different locations. By using Web-based applications, the aforementioned researchers tried to develop and run the prototype by gathering information beyond six scenarios from the National Health Service staff in the UK to test the capability of the IBHIS prototype. Three heterogeneous databases from three universities were used. This prototype provides physicians with a complete picture of the status of a patient to accelerate diagnosis and to provide vital medications. However, the IBHIS prototype faced several challenges in a full-scale operational system, thus leading to a number of modifications in its structure to meet user requirements in viewing integrated information. For instance, Masaud-Wahaishi and Ghenniwa (2009) claimed that the main challenge of IBHIS model is supporting privacy in viewing patient information. They proposed a privacy model for information brokering environment, called privacy-based multi-agent information brokering architecture, to support diversity in the degrees of privacy and to control access to information by a particular user. The goal of the previous two studies, mentioned in this paragraph, was to view integrated patient information from heterogeneous information sources.

Yang, Qin, Jiang, and Liu (2008) presented a new and distributed MISCHV to provide full medical information of patients to authorized physicians and researchers. The MISCHV was developed to share patient information among medical staff, clinics, and research studies by monitoring and providing an integrated database which includes particular cases of a chronic illness, especially patients with viral hepatitis B. The system was also implemented in several hospitals in China based on Web applications using SQL server for the database layer, Microsoft.net for the application layer, and Delphi 7.0 for providing user interfaces. The system is important because it provides physicians and researchers with necessary details related to chronic viral hepatitis. In addition, the system plays a significant role in checking patient status and making follow-ups on cases. However, the MISCHV focuses only on patient status, care, monitoring, and control of chronic viral hepatitis.

To support regional cooperation among different healthcare centre, Heuser, Gerlach, Pollack, and Niederlag (2001) proposed the virtual electronic patient record (VEPR) as a model for integrating patient information within the hospital setting in Germany. The VEPR can be set up as a centralized system. For example, this system was implemented in one hospital to integrate its HISs using Web-based applications with standard interfaces HL7, DICOM, and HTML. The VEPR can also be set up between distinct hospitals as a multiple centralized system. For instance, two hospitals have their own VEPR systems with integrated patient information. The connection between these two independent VEPR systems is needed to view a patient's information when this patient visits the two hospitals. This system allows physicians to quickly access information vital to the patient's diagnosis. The VEPR mainly focuses on integrated patient records among healthcare centres. Kumar, Rao, and Govardhan (2012) proposed the generic information exchange (GIE) system to integrate a patient's EHRs from different sources in various locations. GIE was based on the standard messaging engine implemented with independent platforms. The previous system was designed and developed by preserving heterogeneity, distribution, and full autonomy of each site. The proposed system focuses only on integrating patient information from heterogeneous regional healthcare systems in real-time to support decisions of physicians in treating patients.

Gotoh, Takayama, Ishiki, and Ikeda (2005) proposed an additional cooperative system to support collaborative work among physicians when a patient's problem is not their specialization. The proposed system was based on consultation among physicians by sending patient information to a particular specialist through e-mail fax, or letter. Then, the specialist uses the information as a guide for diagnosis and sends back information to the sender. Lu (2005) proposed a cooperative distributed dental medical system based on a computer supported cooperative work (CSCW) technology focusing on factors such as physicians' cooperation and information sharing, cooperation in resources, and task scheduling. The CSCW system involves dental and medical imaging diagnosis tools, videoconference tools, and electronic patient records. It was designed and implemented as a consultation tool between physician and patient, and to share patient information online among physicians.

Most cooperative HIS models focus on the individual information seeker. Reddy and Jansen (2008) argued that information behaviour in a cooperative medical work environment should support and seek cooperative behaviour not for individuals, but for a group. The same researchers proposed a model of cooperative information behaviour based on the qualitative method of observation and interview tools with caregiving teams in two different hospitals. Based on the results, the researchers concluded that such model needs to consider both individual and cooperative behaviours. A prototype called multi-user search engine was developed by using instant messaging, and search and share features to exchange information and ideas between two users instead of keeping them individually. In this prototype, physicians can send instant message to each other, use search engines to look for information, and share results with others. As such, physicians can only communicate with each other during the research and retrieval process in local and distance locations. The aforementioned study mentioned that both quantitative and qualitative methods have to be conducted to completely understand the nature of cooperative work activities based on user requirements. The multi-disciplinary thematic seminars (MdTS) method was used in (Scandurra, et al., 2008) to support the basis of designing an effective cooperative HIS based on user needs in healthcare systems. The MdTS method was based on seminars with healthcare professionals to study cooperative work activities. Data was gathered using quantitative and qualitative methods through questionnaires, observations and interviews. Then, the researchers explained current and future work in developing HISs based on the analysis of empirical data and prior studies. They also found that integrated patient information, or virtual health records, aggregated from different sources can provide the information needed by medical teams. This study also suggested increasing staff awareness on cooperative work systems to facilitate better care for patients.

Oral communication in cooperative caregiving involves an exchange of information among physicians and nurses. Such communication is used to verbally exchange patient information. However, this type of communication has to be supported by an effective EHR system. Collins et al. (2011) pointed out that oral communication allows physicians and nurses to exchange information among themselves; however, this practice can lead to interruptions and information loss. Furthermore, previous researchers also claimed that this type of communication supports an effective electronic documentation system. Therefore, a model for EHR interdisciplinary information exchange of the intensive care unit was proposed to support verbal communication between physicians and nurses with comprehensive patient information. This model was based on information exchange between physicians and nurses by using observations, interviews, and focus group tools. As a qualitative method, this model was used to collect related data. The proposed model in the study was supported by the development of an EHR tool for cooperative work. Weir et al. (2011) explored the effect of HIS on cooperative work. They found that HISs can be adapted to support user needs in communication and cooperation. Moreover, such systems were more comprehensive and complete in providing healthcare information. Kuziemsky and Varpio (2011) proposed an awareness model to improve the ability to design HISs to support asynchronous inter-professional collaborative care delivery. Ruxwana et al. (2010) studied five rural healthcare centres to determine how information and communication technologies can be used more effectively. This procedure was carried out to improve the healthcare system based on participant requirements by looking at solutions provided by information and communication technologies to achieve cooperation among medical staff in sharing patient information in hospitals. However, Reddy et al. (2011) found that most of earlier HIS cooperative models focused on sharing patient information among physicians.

The aim of earlier studies, which mentioned in this section, was enhancing clinical medical management and physician efficiency. However, none of the earlier research looked into achieving a cooperative system based on a real-time exchange of productive information among physicians. The improvement of physicians' skills by sharing experiences with each other as a decision-support system was not addressed in previous studies. Most of the earlier studies focused on patient information and information on providing better services to patients such as patient follow-ups. However, none of the research looked at developing a cooperative system model to improve physician skills in a timely manner. The challenges encountered are caused by the following factors: 1) each medical unit wished to maintain autonomy in the cooperative HIS environment, 2) a flexible cooperative approach was not the norm in sharing information in such an environment as evidenced from numerous models developed as a centralized database to share patient information among units (Kumar, et al., 2012; Skilton, et al., 2007; Skilton, et al., 2008; Yang, Liu, et al., 2010). The fractal approach is used (Kirikova, 2008; Tharumarajah, et al., 1998; Warnecke, 1993) to overcome such challenges by providing a flexible cooperative approach in developing a system and providing full autonomy to each unit in the system.

2.5 The Fractal Approach

The fractal approach has been used to develop a fractal-based system to solve the problem of lack of flexibility in systems in reacting to internal or external system requirements (Leitão & Restivo, 1999). This approach is also used to model complex systems to reduce the complexity of their structures by increasing flexibility, expandability, and optimization (Zhang, Chen, Sun, & Zheng, 2006). However, previous investigations were dependent on well-established rules for system unit components. In addition, agent-based techniques are used to investigate fractal features in a system. Consequently, Ryu (2003, p.22) defined a fractal system as "a set of self-similar agents, whose goals can be achieved through cooperation and coordination, and can reorganize the configuration of the fractal system to a more efficient and effective one." The details of the fractal concept and its features, agent-based systems, and fractal-based system implementations are outlined in the next sub-sections.

2.5.1 The Fractal Concept

The fractal concept is defined as a shape made of parts similar to the whole in some way. This concept was devised by Mandelbrot to clearly represent the geometry of the complex structure of natural shapes. Each piece in the natural shape represents the entire structure of that shape, such as mountains, coastlines, and galaxies (Hongzhao, Dongxu, Yanwei, & Ying, 2005). Hence, the fractal concept is considered as a system theory to represent system organizations (Arjunan & Kumar, 2007; Kirikova, 2009). The word “fractal” was coined by Mandelbrot and was derived from the Latin word “fractus,” which means breaking or fragmenting (Warnecke, 1993). The fractal theory is based on relationships, emergence, patterns, and iterations (Fryer & Ruis, 2004). It was used by Warnecke (1993) to describe structures and processes of a system in the manufacturing environment. In addition, this theory was used as a method to link system units in distributed manufacturing systems called fractal-based systems. Figure 2.2 shows a fractal manufacturing system with different linked units, representing fractal units (Ryu, 2003).

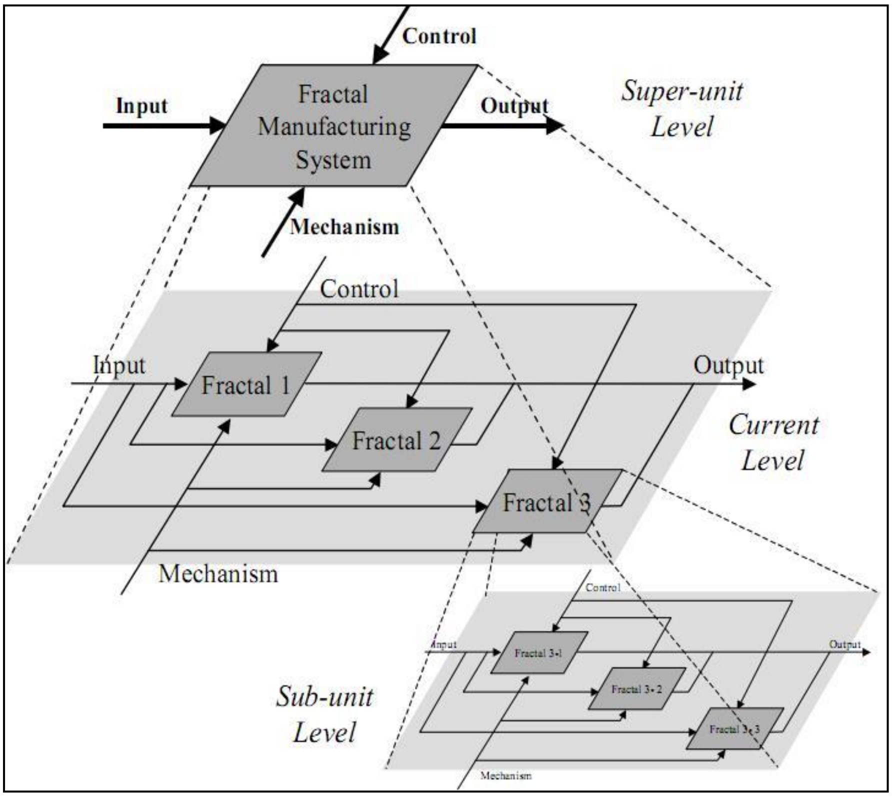


Figure 2.2 : Conceptual Structure of the Fractal Manufacturing System (Ryu, 2003)

The fractal-based system is an open and distributed system (Leitão & Restivo, 1999; Warnecke, 1993), which is the concept for future applications of the Next Generation of Manufacturing Enterprise System Project (Kadar, 2001). The units in a fractal-based system has higher autonomy and more flexibility compared with units in other distributed systems (Tharumarajah, et al., 1998).

The fractal-based system is a conceptual enterprise model that intends to achieve a high degree of flexibility to quickly react and adapt to environmental changes by using decentralized and autonomous organizational units known as fractals (Canavesio & Martinez, 2007; Warnecke, 1993). The mechanism of fractal-based system entities is bottom-up (Warnecke, 1993), whereas higher-level fractals only assume liabilities that cannot be realized by lower-level fractals. The fractal function in a system can achieve cooperation and coordination among its units to fulfil the goals of the system (Tharumarajah, et al., 1998). Therefore, the behaviour of a fractal-based system is more open, autonomic, flexible, and cooperative than conventional systems (Leitão & Restivo, 1999). A simple graphic comparison between fractal and conventional structures is shown in Figure 2.3.

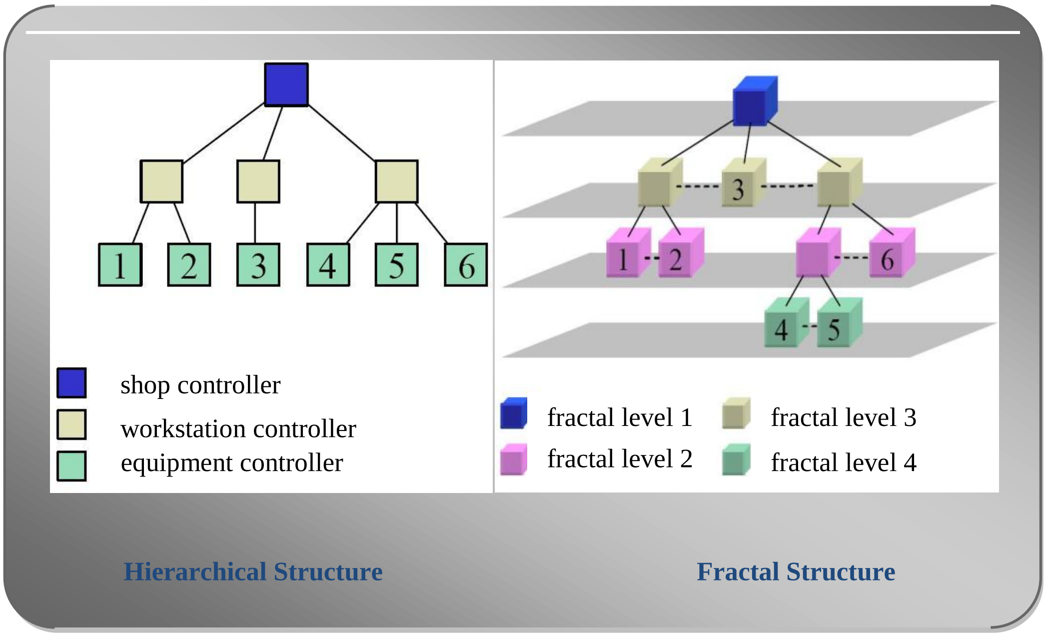


Figure 2.3 : Comparison between Hierarchical and Fractal Control Structure (Ryu, 2003).

The differences between fractal and conventional systems, which depend on hierarchical structures, are summarized in Table 2.1 (Ryu, 2003).

Table 2.1 : Differences between Fractal and Hierarchical System Structure

	Hierarchical structure	**Fractal structure**
Hierarchy	Structured once only, at a specific point in time	Subject to a constant process of change (dynamic structuring)
Component relationship	Administrative higher unit and passive lower units	Coordinative higher fractal and active lower fractals
Job processing	Work according to specified Objectives	Work through the goal-formation process
Unit function	Controllers at the same level in the hierarchy have similar functions	Every fractals have same functional Modules
Adaptability	Suitable for a stable environment	Suitable for a turbulent environment
Flexibility	Not flexible	Flexible

Source: (Ryu, 2003)

A distributed system model can only reflect fractal theory if it possesses self-similarity, self-organization, dynamics and vitality, navigation and goal-orientation features (Tharumarajah, et al., 1998; Warnecke, 1993). Each feature performs a specific function in the operation of a fractal system. A proposed graphical form of the functions of these features is shown in Figure 2.4 (Tharumarajah, et al., 1998).

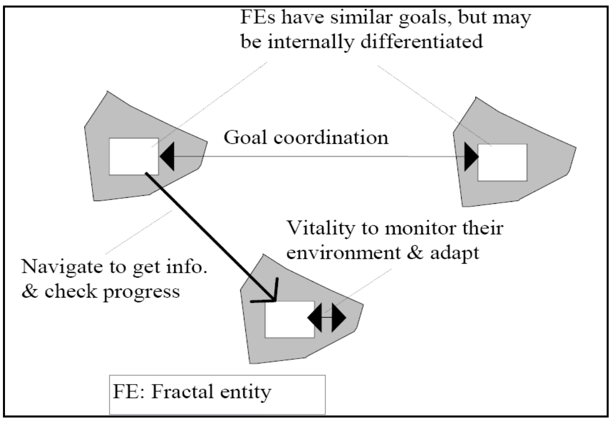


Figure 2.4 : Operation of Fractal Entities (Tharumarajah, et al., 1998).

Numerous researchers have used the fractal approach in different fields to solve problems and to investigate flexibility and quick adaptability to system changes. This approach has led to the creation of animated systems (Mun, et al., 2009). To a certain extent, this concept has been tested in adaptive mathematics (Klonowski, 2000) and manufacturing environments (Castillo & Melin, 2003; Ryu, 2003; Zhang, et al., 2006), image analysis (Klonowski, 2000), enterprise (Xu, et al., 2008), software (Bruneton, Coupaye, Leclercq, Quéma, & Stefani, 2006), IS developments, and other areas to achieve the aforementioned goals (Kirikova, 2008).

2.5.2 Fractal Features

The succeeding sections discuss the main features of fractal theory, which have been reviewed to support the objectives of this study.

2.5.2.1 Self-similarity

The self-similarity feature refers to all units in a fractal system having the same structures or goals (Canavesio & Martinez, 2007; Warnecke, 1993). Self-similarity is defined as the ability of system units to produce similar outputs from similar inputs using different internal procedures and structures (Ryu, 2003). Each unit in a fractal system contains a set of similar components and properties (Clancy, 2008), and shares a set of objectives and visions (Kadar, 2001) to investigate the flexibility structure (Kirikova, 2009). The existence of this feature in any system provides flexibility; however, possessing this feature alone is not sufficient for a system to be considered fractal (Warnecke, 1993).

2.5.2.2 Self-organization

Self-organization refers to the freedom of fractals in organization and implementation functions (Warnecke, 1993). If a system has this feature, it does not need an external intervention to reorganize itself (Leitão & Restivo, 1999). Fractal units can choose their own problem-solving methods including self-optimization, thus leading to processing enhancements (Kadar, 2001; Tharumarajah, et al., 1998). Each unit has sufficient freedom to execute activities in the system (Canavesio & Martinez, 2005). Fractal systems do not have a hierarchical structure of control and command. However, constant reorganization occurs to determine the best fit with the environment (Fryer & Ruis, 2004). This feature is used to justify the autonomous characteristics of fractal units in fractal systems.

2.5.2.3 Dynamics and Vitality

Dynamics and vitality features are used to dynamically investigate the system (Warnecke, 1993). Dynamics refers to the ability of the fractals to adapt to changes in the environment without any challenges to the formal structure of the organization (Kadar, 2001; Tharumarajah, et al., 1998). Information can be updated among system units whenever needed (Xu, et al., 2008). Vitality refers to the behaviour of a fractal that can be considered as an organic unit searching for new activities from other units in the system (Ryu, 2003). This feature monitors environmental changes and helps the system quickly adapt to these changes (Tharumarajah, et al., 1998). However, the concept of this feature focused on uniting operations among fractals to obtain a dynamic system.

2.5.2.4 Navigation

The navigation feature induces cooperation among fractals (Tharumarajah, et al., 1998). Thus, the fractal network works via an efficient information and communication system

(Warnecke, 1993). This feature is used to obtain information and to check progress (Tharumarajah, et al., 1998). The navigation feature coordinates fractal units to obtain goal-orientation characteristics.

2.5.2.5 Goal-orientation

The goal-orientation feature enables the goals of the system to emerge from the objectives of individual fractals (Warnecke, 1993). This feature is used to satisfy all members in the system by providing a goal-consistent process among participating fractals. The goal-orientation feature is supported by an inheritance mechanism (Ryu, Son, & Jung, 2003a). Fractal processes can exchange information and motivate one another in the system to achieve better service processes (Yuanping, Jun, & Huaying, 2008). The aim of this feature is the acquisition of new knowledge by propagating information among system units (Xiuquan, Jinmei, & Haorun, 2009).

2.5.3 Agent-based Systems

The multi-agent system concept is derived from distributed artificial intelligence. This concept can be defined as a set of nodes, designated by agents, that represent units of the system (Ferber, 1995). No unique definition for the term "agent" exists. However, an agent can be defined as a component of a software or hardware that possesses autonomy and intelligence. The capability to communicate and cooperate with other agents to accomplish functions is possible (Parunak, 2000). The multi-agent system is suitable for distributed systems. The agent-based architecture, as depicted in Figure 2.4, has the following features (Leitão & Restivo, 1999):

1. Autonomy: An agent can operate without the direct intervention of external entities and has control over their behaviour.
2. Cooperation: Agents interact with other agents to achieve a common goal.

3. Re-activity and pro-activity: Agents quickly perceive their environment and respond to changes that occur in it. However, agents do not simply act in response to their environment, they are able to take the initiative and control their behaviour.
4. Adaptation and decentralization: Agents can be organized in a decentralization structure, and can easily be reorganized into different organizational structures.

Based on the aforementioned features, agent-based systems are used to investigate fractal features in a system. An “agent” is a part of a software or hardware that possesses autonomy, intelligence, and communication capability. An agent-based system enables the cooperation among agents to accomplish functions (Parunak, 2000). A multi-agent system is suitable for distributed systems, especially fractal systems (Rajan, 1996).

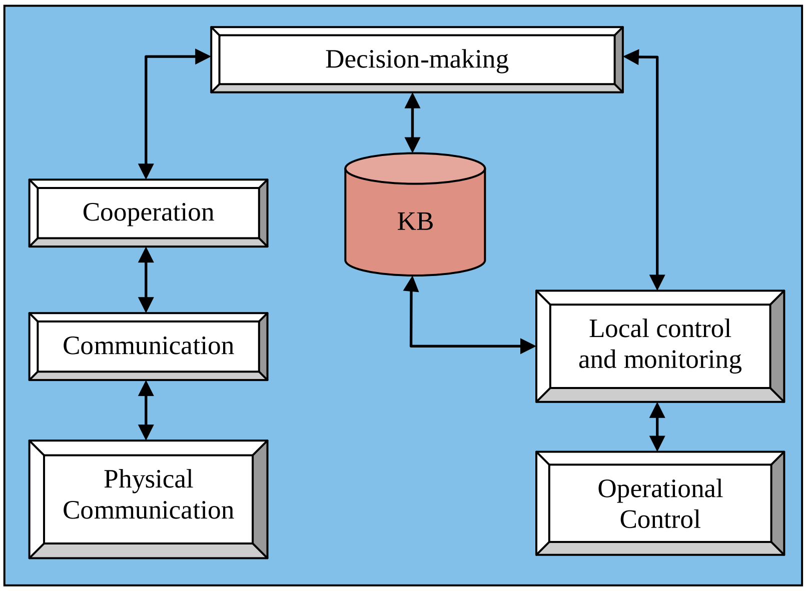


Figure 2.5 : Generic Model of an Agent (Leitão & Restivo, 1999)

2.5.4 Fractal-based System Implementations

A fractal-based system has been proposed by researchers in different fields. Such system is developed based on fractal theory and its features. The main goal of the fractal-based system is to provide a flexible and cooperative system as decentralized and autonomous system units known as fractals (Kirikova, 2008; Tharumarajah, et al., 1998).

In the field of manufacturing, Rajan (1996) proposed an agent-based fractal model to make the decision-making structure in manufacturing enterprises more flexible among their units. Each level of manufacturing enterprise has units represented as fractals (agents). Connections among fractals at similar and higher levels are established to select effective decision-making processes, as shown in Figure 2.6. This decision is selected to quickly respond to system changes, such as organizational structures, procedures, and systems in one level of the manufacturing environment and propagated to the next high level by means of clearly defined interfaces.

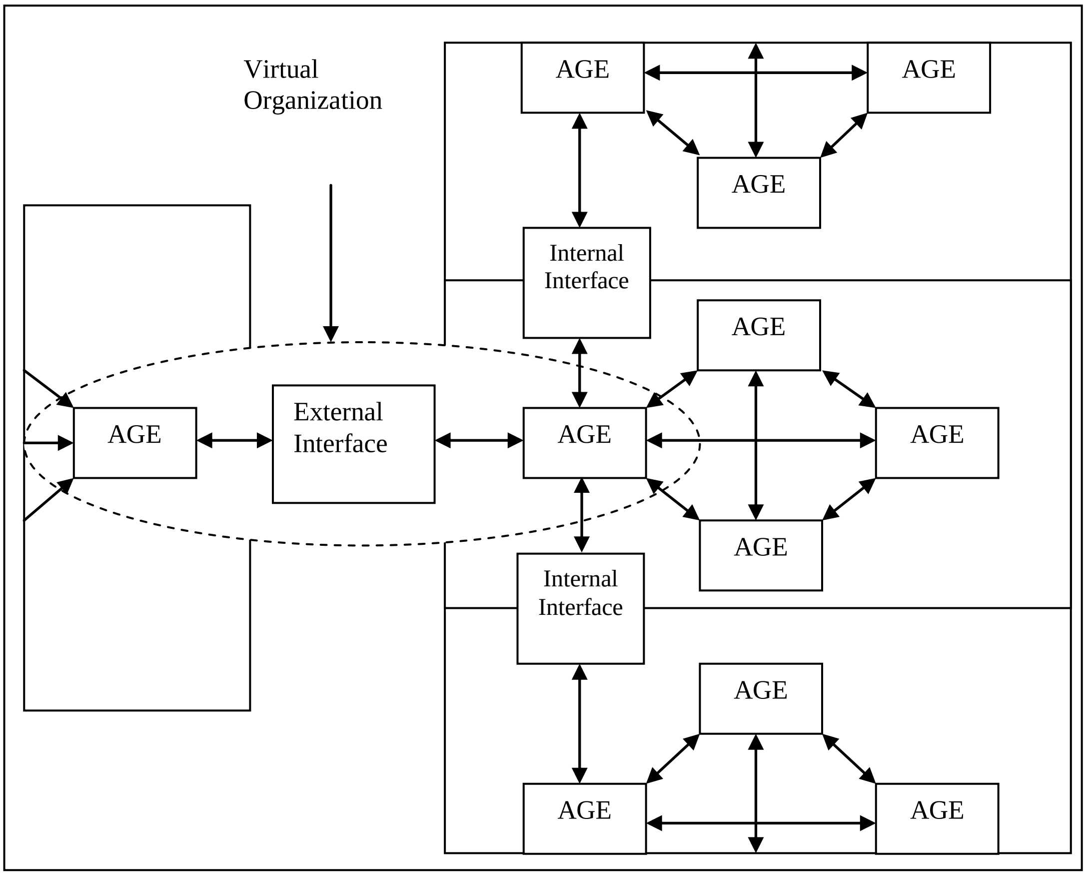


Figure 2.6 : Agent-based Fractal Model of the Agile Manufacturing Enterprise (Rajan, 1996)

Ryu, Son, and Jung (2003b) proposed a fractal model using a multi-agent technique, wherein each unit in a manufacturing system represents a fractal (agent). Each fractal unit consists of five modules (observer, analyzer, organizer, resolver, and reporter), as depicted in Figure 2.7.

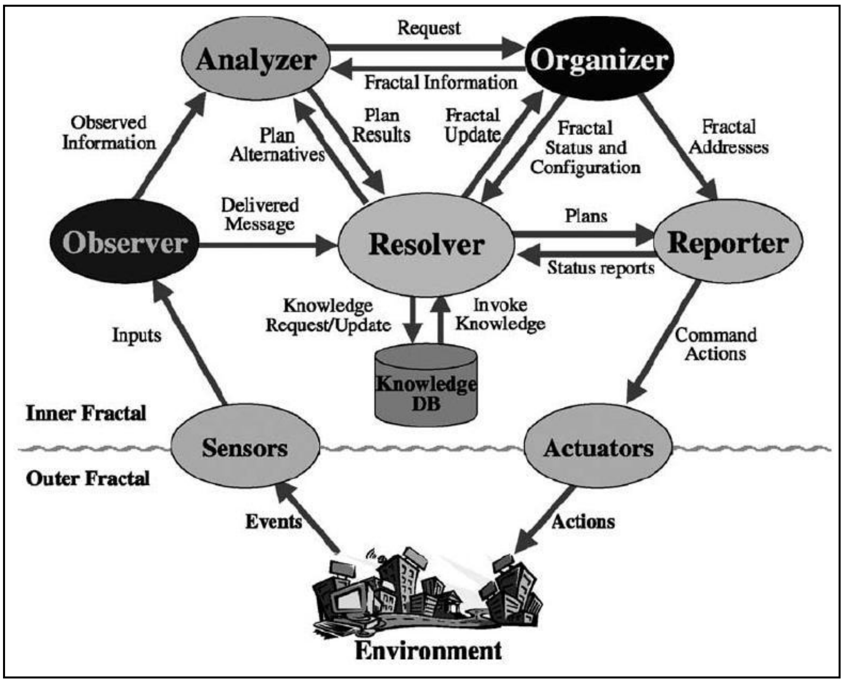


Figure 2.7 : Functional Modules and Relationships of a Fractal in an Fractal-based Manufacturing System (Ryu, et al., 2003b)

In Figure 2.7, modules work together to form fractal actions at different system levels. All fractals have similar modules to investigate the self-similarity feature in a system. The same researchers used self-organization to optimize the performance of fractals in the system to support the reorganization of its network connections. Thus, the system can be optimized and adapted to a dynamically changing environment. Furthermore, the aforementioned researchers used goal-orientation to achieve a coordinated goal among fractals. The main goal of the previously discussed proposal is to increase flexibility and adaptation of control systems in the manufacturing environment to satisfy dynamically changing customer requirements.

Shin, Mun, and Jung (2009) proposed the self-evolution model of manufacturing systems based on fractals. This model is used to control the dynamic structure of production resources to quickly satisfy environmental changes, such as new orders or changes in demand. The units of this model are adapted as fractals called autonomous and intelligent resources (AIR). Each AIR unit is autonomous in decision making and collaborates with the other units to complete the goal of the process. The function of this model is manifested in independent goal-orientation and dynamic structuring of the system. The model also requires an in-depth research to adapt all fractal features to obtain a more applicable system.

In the field of business, fractal features have been proposed for adaptation into modern business management. Each unit in a business system is represented as a fractal that acts autonomously, referring to the company itself and several other companies (Sihn & Klink, 2001). Ryu et al. (2003a) used the fractal model in the supply chain management of e-business companies, wherein each member in the supply chain is modelled as a fractal (see Figure 2.8).

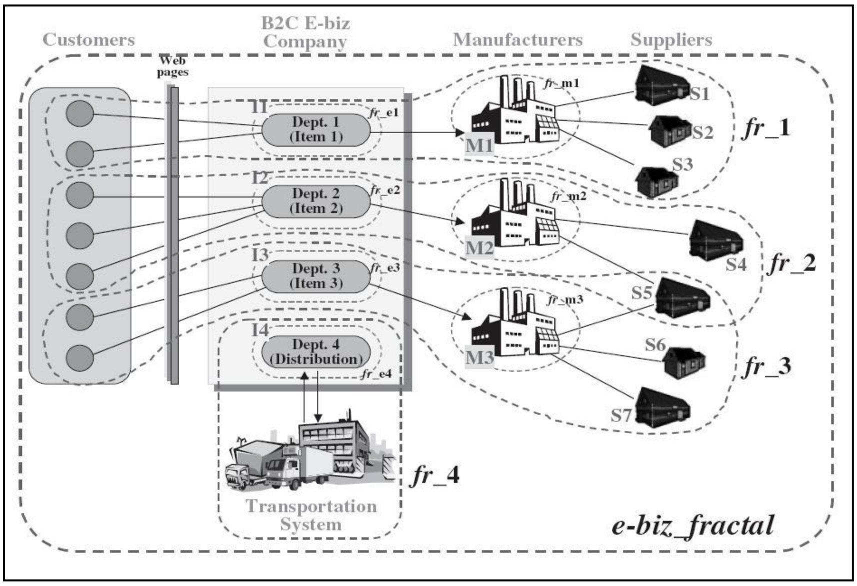


Figure 2.8: Composition of Fractals in Fractal Supply Chain Management (Ryu, et al., 2003a)

In Figure 2.8, each fractal has the same modules (e.g. fr_1, fr_2 and fr_3). The functions of these modules depend on the field of work. The goal of this model can be easily understood and can be used to manage activities among members of the supply chain. The aforementioned researchers also tried to solve general problems in supply chain management, such as difficulty in responding to customer requirements. This model can be used to adaptively respond to dynamic customer requirements to a certain extent.

Canavesio and Martinez (2007) suggested a fractal model to establish small and medium enterprise networks and to achieve a flexible project management system. This model posits that each project management unit can be represented as a fractal. Thus, each unit has self-organization and self-learning, and is a goal-driven entity. Collaboration among these different expertise units is mapped to achieve a concrete system goal. The fractal management unit is depicted as an agent with six modules: monitor, analyzer, reporter, planner, executor, and knowledge base (see Figure 2.9).

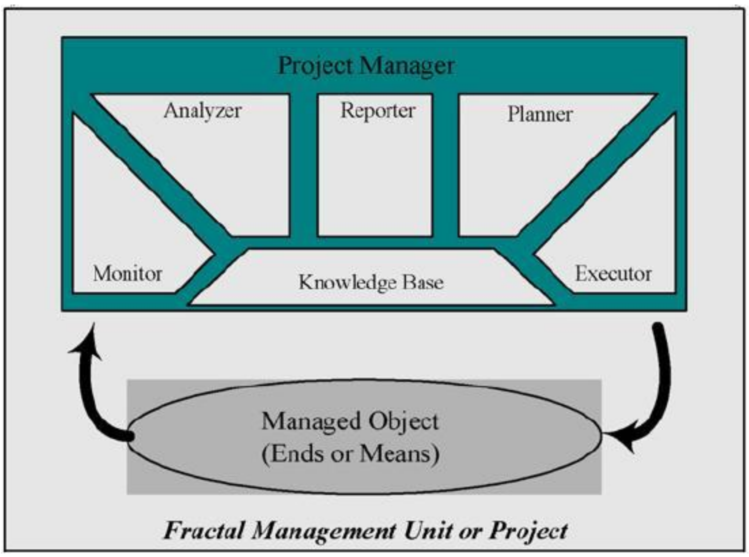


Figure 2.9: Internal Structure of a Project as a Fractal Management Unit (Canavesio & Martinez, 2007)

In Figure 2.9, the fractal management unit and its six modules work as a project manager and a managed object. The project manager has autonomy to control and execute local activities and cooperate with other project managers to achieve the project goal. Furthermore, the managed object has a partial role in produced as a whole project. Each managed object can be saved in a knowledge base module of each unit to be acquainted by other project managers from other units and to be used as knowledge for further projects. The communication among fractal management units can be done temporary and based on the project requirements to provide flexibility in the project management. In the enterprise networks, this communications of units can be achieved in abstract levels based on the fractal approach (see Figure 2.10).

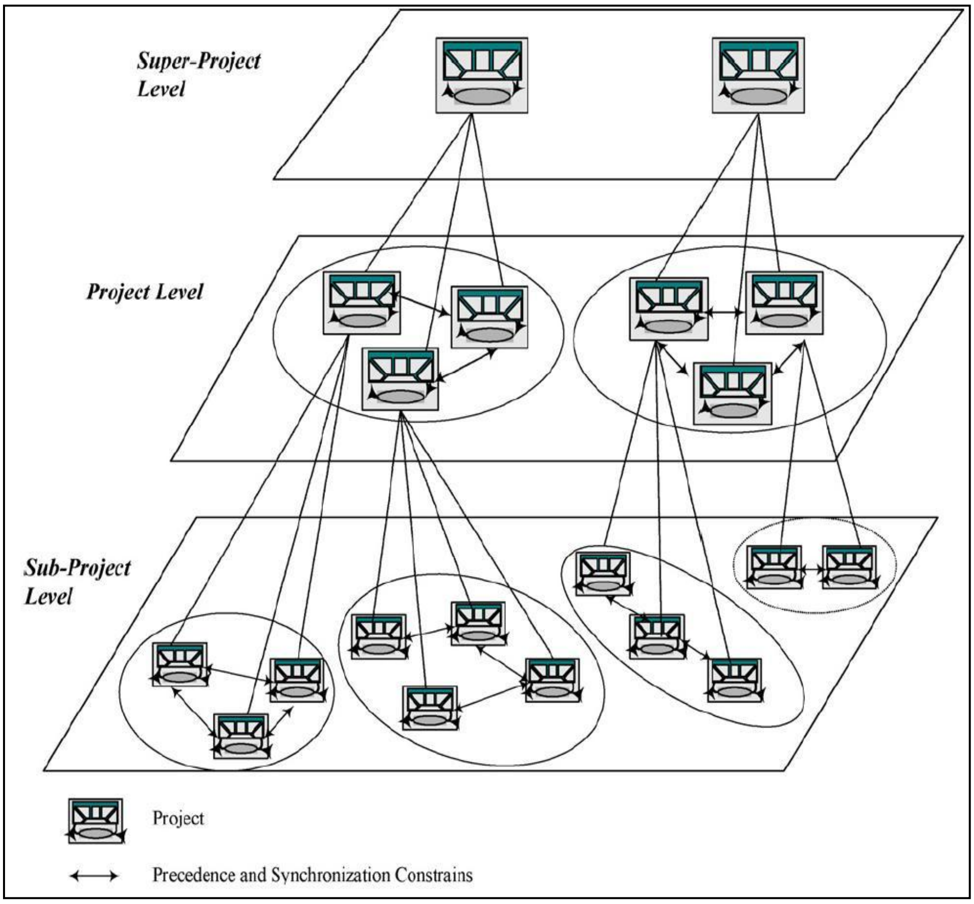


Figure 2.10 : The Recursive Relationship in the Project-based Fractal Company (Canavesio & Martinez, 2007)

In Figure 2.10, a whole project can be divided into sub-projects as levels of project. These levels are super-project, project and sub-project to easily manage and control the project among different enterprises. The figure shows the levels of fractal model and fractal management unit components. The goal of this model is to achieve a higher degree of flexibility of connection among system units. Therefore, this model, which is composed of fractal features with different modules and processes, can be applied in any environment. The aforementioned model of fractal management units and its modules also can be used as method to link any system units to easily manage and control local activities and quickly disseminate these activities among system units to provide an effective cooperative system.

An enterprise needs to adapt quickly to meet customer demands (Shin, et al., 2009). Yuanping, Jun, and Huaying (2008) proposed a service integration model based on the fractal approach to improve cooperation among staff in easy and quick means. This model proposes to manage and integrate service processes in service companies to satisfy customer demands. It describes each customer request as a fractal service process. This fractal has the same structure and contains standard service modules. Each fractal unit can be constantly self-optimized, self-adapted, self-created, and self-organized during the implementation process.

The competencies of an enterprise have been modelled based on the fractal approach by Xiuquan, Jinmei, and Haorun (2009), who suggested that the fractal model can efficiently improve enterprise competence by the acquisition and creation of new knowledge. The mechanism of this model is mathematically descriptive and divides competencies into four fractal units: activity, process, operator, and team. These units use the same knowledge storage that depends on the operation activities conducted by system units. This model facilitates the operation of determined competencies of each enterprise. The fractal approach was also used by Xu, Zhao, and Yao (2008) to decrease difficulty in tracking and controlling the processes of an enterprise. The aforementioned researchers used the fractal mobile agent to represent the tracking and control process at each level of the workflow structure. Each fractal mobile agent has the same work structure to transfer a specific type of information to other agents. Through this agent, the complexity of the tracking and control process is divided into several sub-processes. Thus, the difficulty of the inter-enterprise quality tracking and control is decreased.

Business process activities were modelled as business fractals in (Rensburg & Antonie, 2009) to improve manager performance in an organization. Business fractals were divided into two dimensions: static and dynamic. The static dimension includes pattern and content. Pattern is a content unit that has data, information, and knowledge about the business system. The dynamic dimension includes memory and volatility. Memory is information that is always updated depending on activities. Volatility defines fractal behavior. This model improves the knowledge of the manager in understanding and studying the business process to increase the organization performance.

A virtual fractal enterprise model was proposed in (Mun, et al., 2009). The model aimed to increase trust between partners in virtual enterprises and to select the best partners in a collaborative environment. The structure of this model is flexible; therefore, the ease of adding and removing units depends on the trust value of the unit evaluated by this model. Each unit can be represented as a virtual fractal enterprise. These units have the authority to automatically exchange information.

A fractal enterprise approach was proposed by Stecjuka, Makna and Kirikova (2008) to increase the flexibility of a business process in organizational operation and development. This approach allows selection of the best practices of a business process among fractals, such as an annual report of the scientific activities of institutions. These fractals are organized in a hierarchical structure, as shown in Figure 2.11.

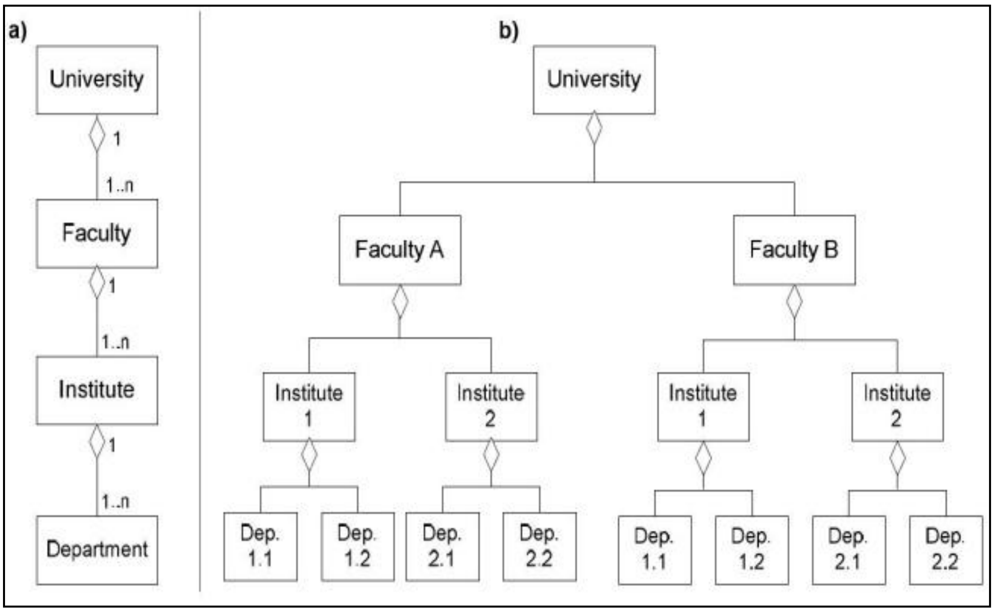


Figure 2.11: Fractals (University, Faculty, Institute, Department) in the University (Stecjuka, et al., 2008)

In Figure 2.11, each unit has high autonomy in selecting its operations. For instance, the university fractal requests an annual report from its low levels down to the department level fractals. Department fractals are free to achieve this goal. The preparation of the report depends on the system practices of each department. The best way to accomplish this process is by comparing and selecting among departments. This selection is propagated to all fractals at the same level. These practices are imposed upon higher organizational levels by an appropriate unified IS design for all units. The flexible approach can solve problems caused by modifications, such as changes in universities and in the local high-education system. Based on such reasons, Binsztok and Leja (2006) proposed the university as a fractal organization of knowledge. They used the fractal model in the university environment to improve member qualifications by quickly sharing knowledge. However, the aforementioned researchers merely adapted the fractal approach in the university environment without strong practical evidence.

In any IS environment, a fractal-based IS must have fractal features. Warnecke (1993) expected IS studies to adapt the fractal approach because the IS environment continuously needs changes and updates in structure and information depending on environmental requirements (Kirikova, 2008). ISs consist of decentralized and autonomous process units (Asnina, et al., 2008). These units are composed of computer software and humans. They can retrieve and update data to provide information as required (Kirikova, 2008). Therefore, Warnecke (1993) believed that the components of an IS could function as fractal units to create a flexible vitality system and a less complex work system. Thus, the fractal concept has been used in several ISs to achieve flexible system structures, as well as easy management and control of system process activities (Canavesio & Martinez, 2007; Ryu, et al., 2003a; Shin, et al., 2009; Xu, et al., 2008; Yuanping, et al., 2008).

The main function of an IS unit is to process knowledge, information, and data. Each unit can provide information (services) to other units to achieve system goals (Kirikova, 2008) and to provide concrete collaboration as a fractal approach (Tharumarajah, et al., 1998). As fractals, connection and interaction between these units maintain system continuity because such connections and interactions depend on the manner of disseminating information between fractal units (Fryer & Ruis, 2004).

An important benefit of the fractal-based IS is the maximization of information flow and storage among fractal units (Ryu, 2003), as shown in Figure 2.12.

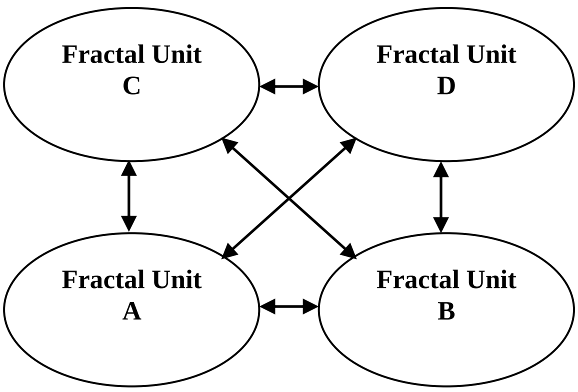


Figure 2.12: Method of Information Transmission between Fractal Units (Yuanping, et al., 2008)

Information flow and storage are achieved in numerous ways, such as information flow inside the fractal itself, among same-level fractals, different-level fractals, fractal entities, and external environments (Tharumarajah, et al., 1998). Information flow between fractals and the external environment is used to increase collaboration characteristics among fractals. This collaboration style is used depending on the six specific work environment levels: cultural, strategic, socio-informal, financial, informational, and technological (Tharumarajah, et al., 1998). In addition, a number of factors are involved in a successful collaborative environment, such as context, support, tasks, interaction processes, teams, individuals, and overarching (Patel, Pettitt, & Wilson, 2011).

To motivate fractal theory in ISs, Kirikova (2008) extracted several guidelines for adapting the fractal approach in developing ISs. These guidelines were devised based on previous fractal studies and fractal properties in ISs. These properties and guidelines have been discussed in previous studies. Moreover, Kirikova also mentioned that the important features in adapting a system into a fractal are self-similarity, self-organization, goal-orientation, and dynamics and vitality. This adaptation leads to the creation of an integrated fractal-based IS.

Kirikova (2009) used the fractal approach in an IS to achieve flexibility in the information architecture to strengthen the evidence. The same researcher focused on educational institution units in a university. The structures of these units are similar. However, the units are organized in different scales as a bottom-up fractal structure, as shown in Figure 2.11. In this structure, high-level units acquire information from low-level units. In the previous work, fractal features were used to develop integrated fractal-based ISs. In such systems, each unit has a similar knowledge structure. Kirikova used self-organization to represent software procedures in each unit. Dynamics and vitality features were used to monitor changes in the fractal entity. Tacit knowledge is changed to explicit knowledge. This change is propagated to all fractals, especially in the information architecture. Tacit knowledge is obtained using internal individual processes stored in human beings, whereas explicit knowledge is stored in computers, such as database systems (Abdullah, et al., 2005). The purpose of this research was to ensure that information integrity is not lost during system changes.

The main goal of establishing a cooperative environment in a system is to enhance the skills of the members because individual work is often incapable of satisfying all requirements (Mun, et al., 2009). Stecjuka, Makna, and Kirikova (2008) proposed a fractal model to select the best practices, such as an annual report of scientific activities in universities, and to propagate these practices among fractal units in the same level. This kind of cooperation between fractal units is used to improve operational skills by acquiring new knowledge.

Integrated fractal-based ISs have fractal features, such as self-similarity, self-organization, goal-orientation, navigation, and dynamics and vitality. This type of system consists of decentralized and individual fractal units (Tharumarajah, et al., 1998; Warnecke, 1993). Each fractal unit can be represented as an agent (Ryu, et al., 2003b). Cooperation among agents is an important action in a fractal IS to attain the system goal (Tharumarajah, et al., 1998) and improve operations (Stecjuka, et al., 2008). A few researchers have used the fractal approach in IS domains. Previous studies merely used the fractal approach within the manufacturing, enterprise, and university environments. Moreover, several studies are still in their early stages. HISs are similar to ISs involving decentralized and autonomous units (Yang, Liu, et al., 2009), and can be considered as fractal systems (Clancy, 2008; Fryer & Ruis, 2004). Clancy (2008) mentioned that social organizations, such as hospitals, can be represented as biological systems to optimize distributed information in intranet networks between hospital units. Clancy adapted hospital networks as biological systems based on the self-similar fractal feature.

However, no structure or model has yet described optimization of the flow of information among similar units.

2.6 Cooperative HISs as a Fractal

Healthcare systems in many countries generally have distributed structures and consist of individual centres supported by autonomous HISs, such as hospitals. Cooperation among medical staff, especially among the physicians, in such healthcare systems is an important issue in sharing information and skills in the patient treatment to improve skills of physicians and patient outcomes. In addition, HISs serve as bases for exchanging healthcare information among physicians and provide integrated patient information for physicians within same and between different hospitals. Each HIS has the autonomy to process activities of patient treatment but can also work cooperatively with other HISs to exchange healthcare information among physicians and provide a quality care for patients. Therefore, a flexible cooperative approach to link HISs within the hospital and in different hospitals is required to provide an effective cooperative HISs environment.

The earlier studies (see section 2.4) on developing cooperative HIS models focused on patient information and information with regard to providing better services to patients, such as patient follow-ups. These models were improving clinical medical management and physician activity. Most of these models have developed databases containing integrated patient information as a centralized system to exchange this information among medical staff within the hospital. Some of the cooperative HISs models have developed in sharing healthcare information among practitioners at different locations, but also as the centralized system to concentrate on the problems of a particular patient. However, none of the earlier studies looked at developing cooperative HIS models to improve physician skills to provide quality care to patients and to enhance healthcare services. This situation occurred due to some significant factors affecting cooperation among physicians in sharing information and skills in patient treatment within the hospital and in different hospitals. These factors are shown in the following:

1. A large amount of data is difficult to manage and control in a paper-based and centralized system. As such, healthcare systems in many developing countries, including Iraq, still use manual systems. Moreover, these systems are also mostly hospital-based and centralized (Ali, et al. 2011; Gaboury, et al. 2009; Hameed, et al. 2008; Mengiste 2010; Scandurra, et al. 2008; VanVactor 2011; Yang, Liu, et al. 2010).
2. Cooperative HIS units wish to maintain autonomy. Because of the fragmented nature of healthcare systems, HISs are isolated from one another and are developed for a particular unit in a hospital. Thus, current cooperative HIS models were developed based on a centralized control system, thus resulting in less autonomy for each unit in the system, as shown in the literature, (Kumar, et al., 2012; Skilton, et al., 2007; Skilton, et al., 2008; Yang, Liu, et al., 2010).
3. A flexible cooperative approach is not the norm with regard to sharing information for most cooperative HIS models being developed at present. This outcome happened because such models have developed as a centralized database for sharing patient information among system units (Reddy, et al., 2011).
4. New knowledge is not acquired in a timely manner by physicians within the same hospital and in different hospitals. The reason for such situation is the goal of earlier studies which focused on enhancing clinical medical management and physician efficiency by sharing patient information among physicians. However, previous studies did not address improvement of physician skills by sharing their

experiences with each other (Reddy & Spence, 2008; Skilton, et al., 2007; Weir et al., 2011; Yang, Liu, et al., 2010).

5. Physicians in hospitals work independently because of time factor. For instance, in Iraqi hospitals, professional physicians work for only three hours, thus they have to attend to a large number of patients. As such, these physicians do not have time to meet each other and discuss skills in patient treatment (Ali, et al., 2011; Alwan, 2004).
6. Weak activities of R&D units within a hospital lead to lack of information sharing among physicians. This result happened because R&D units can manage and control hospital activities, especially physician activities, with regard to patient treatment and disseminate such activities among physicians to improve their performance (Chiesa, et al., 2004; Collins, et al., 2011; Kuziemsky & Varpio, 2011).

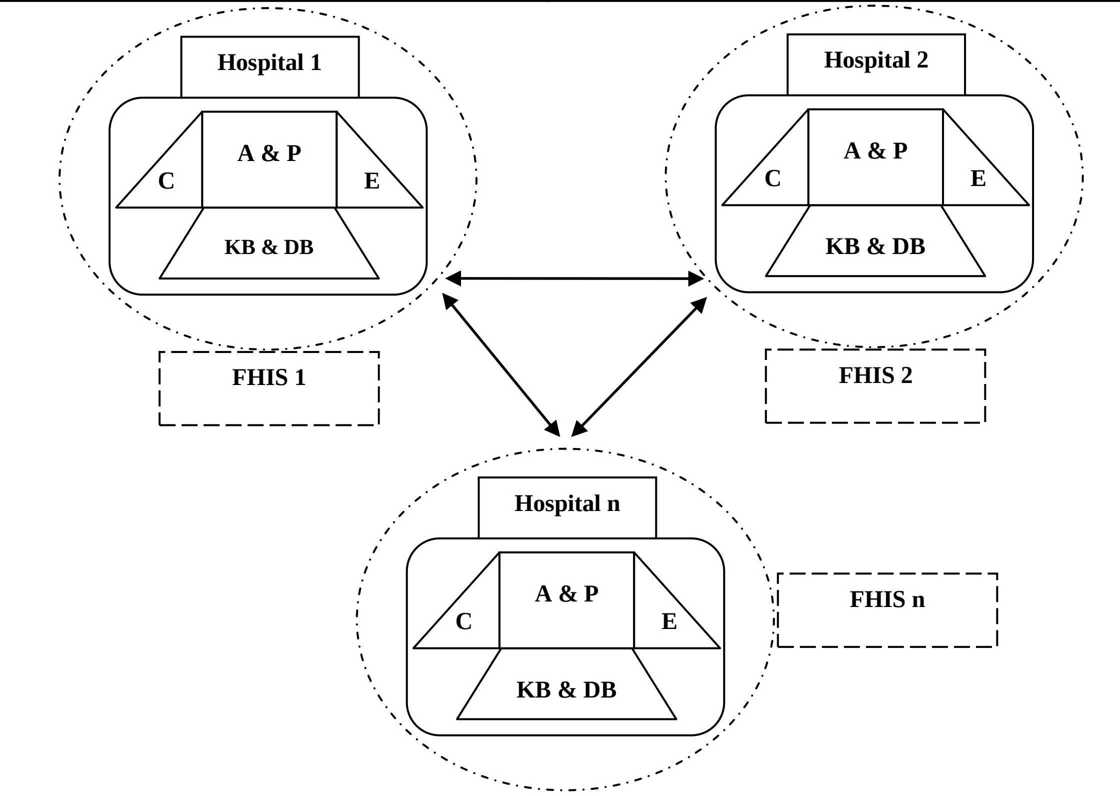
In addition, in most developing countries, such as Iraq, cooperation among physicians with regard to sharing information and skills in patient treatment within the hospital setting is still very poor. Such poor cooperation can lead to insufficient outcomes and research studies in hospitals where lack of medical skills can lead to harmful effects.

Based on the literature review of this study (see section 2.5 and its sub-sections), the fractal approach has been successfully used in designing integrated cooperative ISs which provide an open, autonomic, flexible, and cooperative method for linking system units. This approach on developing a system has been compared with conventional systems, and has been found that the fractal-based systems are more flexible, autonomic and cooperative than conventional ones (see Figure 2.3). The fractal-based systems can be contained similar units arranged in abstract levels (see Figure 2.2, Figure 2.6 and Figure 2.9). Each unit as a fractal in such systems has same modules and goals to achieve a flexible structure. Each fractal unit also has full autonomy in their process activities, and can cooperate with other fractal units to achieve system goals (see Figure 2.7, Figure 2.8 and Figure 2.10). This cooperation among fractal units can be done through the method of information flow and storage (see Figure 2.12). The fractal-based systems have five important features, such as self-similarity, self-organization, dynamics and vitality, navigation and goal-orientation. Each feature can perform a specific function in the operation of such systems. A distributed system model can only reflect fractal approach if it has the aforementioned features. Furthermore, agent-based system techniques (see section 2.5.3) have used to investigate fractal features in a system and represented each fractal unit as an agent.

In addition, HISs are found to be similar to ISs that involve decentralized and autonomous units. HISs could be considered as fractal-based systems for achieving a cooperative environment with regard to sharing healthcare information among healthcare centres. Developing cooperative HISs based on the fractal approach can overcome previous factors by providing: 1) high autonomy for each unit, which decreases global control, and facilitates management and control of data within decentralized units, 2) flexibility to the structure and functionality among units by connecting similar units in the structure or goals, 3) concrete cooperation through monitoring and propagation of new actions among units of a system to obtain information and check progress in real-time, and 4) strategic goals of the system and enhanced decision-making processes by users. Therefore, the researchers in this study proposed a conceptual framework for integrated cooperative HISs based on the fractal approach, called the FHIS model, as shown in Figure 2.13.

Self-similarity: To increase the flexibility of the structure and functionality between units.

Self-organization: To provide high autonomy for each unit, this decreases global control.



C: Controller Module, **A&P**: Analyzer and Planer Module, **E**: Executer Module, **KB&DB**: Knowledge-base and Database Module.

FHIS: Fractal Healthcare Information System.

↔ : Information Flow.

Dynamics and Vitality: To monitor and propagation new actions between units of a system .

Navigation: To get information and check the progress in order to obtain an integrated information system.

Goal-orientation: to achieve the strategic goals of the system and enhance decision-making by the physicians.

Figure 2.13 : Conceptual Framework of Integrated Cooperative HISs Based on the Fractal Approach

The FHIS model has to possess fractal features to develop cooperative HISs based on the fractal approach. The operation of units (that is, FHIS units) in this model has been extracted from the five features of the fractal approach and based on the operation of fractal entities discussed previously in this section. First, the self-similarity feature of the fractal approach was used to increase the flexibility of the structure and the functionality between healthcare system units. This procedure was performed by connecting similar units in the structure or goals because the aim of healthcare centres is to provide effective healthcare services to patients. Second, the self-organization feature was used to provide high autonomy for each unit by connecting decentralized units as fractals, which decreases global control. Third, the dynamics and vitality features were used to monitor and propagate new activities among units of a system in a timely manner. Then, the navigation feature was used to obtain information and to check progress within similar and among different FHIS units to obtain an integrated IS. Finally, the goal-orientation feature was used to achieve the strategic goals of the system and to enhance the decision-making skills of physicians through the acquisition of new knowledge from other physicians.

In Figure 2.13, the contents of each FHIS unit were adapted from functional modules and relationships of fractal entities. The goal of this adaptation is to manage and control hospital activities, especially physician activities, and to propagate such activities among physicians within the hospital environment in real time. The operation of each FHIS unit can be carried out by including: controller (C) module, analyzer and planner (A&P) module, executer (E) module, and knowledge-base and database (KB&DB) module. The C module of the FHIS unit can monitor any new activity of physicians that happened in the hospital. This module sends a message about the new activity to the A&P module. The A&P module tries to analyze the activity by considering inner or outer unit activity. If it is an inner activity, the A&P module plans which data is related to the activity by navigating the DB of KB&DB module to announce the E module of the data related to this new activity. Then, the E module obtains the complete data announced by A&P module from the DB and save it as knowledge in the KB. Afterwards, the E module sends the announcement about the new activity to other FHIS units in the system to consider this new activity as new knowledge. If the activity came from the outer unit, the A&P module sends the message to the E module to create a view on the new activity. By using this mechanism in propagating new activities as knowledge among FHIS units, physicians in each unit can be supported by providing efficient information related to their job to improve their performance by acquiring new knowledge in real time, any time.

The literature in this study showed that agent-based techniques have been used to investigate fractal features in a system. Hospital activities, especially physician activities in patient treatment, can be managed and controlled by R&D units (see section 2.3.1) to ensure cooperation among physicians. As such, the researchers in this study have used an agent-based technique to develop an FHIS model and have represented each unit of the FHIS model as an R&D agent.

Based on studies by Scandurra et al. (2008), Weir et al. (2011), Kuziemsky and Varpio (2011), and Ruxwana et al. (2010), the development of effective cooperative HISs to support cooperative work among medical staff, especially among physicians, need real users. This result is based on the fact that the cooperative HIS approach requires appropriate, flexible and comprehensive healthcare information based on physician requirements. The previous studies also mentioned that data collection from different sources as quantitative and qualitative methods can provide integrated information needed by medical staff. Furthermore, the development of a model to link the HISs among hospitals to improve cooperation among physicians is a new research area in Iraq; thus, local literature on this particular subject is limited. Therefore, this study uses mixed methods of research for data collection to address research questions. The data collection in the study has been carried out in the Kurdistan region of Iraq, as a case study. In conclusion, cooperative HISs based on the fractal theory and its features can provide an open, autonomic, flexible, and cooperative system that can improve cooperation among physicians in sharing information and skills in patient treatment within the same hospital and among different hospitals.

2.7 Summary

The chapter served as an overview of ongoing and previous studies related to this research. It concentrated on analyzing areas of cooperation among physicians in sharing information and skills in patient treatment. The literature review identified several important studies on topics regarding the use of electronic HISs to meet physicians' needs for cooperation in the hospital environment to support their decisions in patient treatment and to provide quality healthcare services. Many researchers in this area proposed centralized system models for sharing patient information among medical staff; however, such models are not flexible in structure, are difficult to manage and control because of the enormous data in complex healthcare systems, and have less autonomy.

Based on literature review, cooperation among physicians is lacking because of significant factors observed in this chapter (see section 2.6). The fractal approach to develop cooperative IS is described and obtained to overcome such factors affecting cooperation among physicians and to develop effective cooperative HISs, thus enhancing physician skills and consequently, improving healthcare services.

The next chapter will describe the methodology used in this study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter details the research strategy and methods used in the collection of data to achieve the objectives of this study. It begins with a description of the research strategies and the research paradigms. Then, it follows by the research methods section. This section includes details of the design and creation of the data collection instruments, and the methods used in data collection and analysis. The subsequent section explains the testing of the validity and reliability of the instruments. Then, the selected study population and sample, as a case study, are detailed. Finally, the development of Fractal-based Healthcare Information System (FHIS) model that is proposed in this study is detailed.

3.2 Research Strategies

The strategy of any research design refers to a set of procedures or methods used in conducting research. There are three types of research strategies: quantitative, qualitative, and mixed methods (Mingers, 2001). These research strategies are based on some underlying “paradigms”, as philosophical assumptions, to guide the research and find appropriate research methods. Taylor, Kermode, and Roberts (2006, p.5), defined a paradigm is “a broad view or perspective of something”. The aforementioned researchers also mentioned that some researchers called the paradigm as a “world view”. According to Weaver and Olson (2006), the paradigms most commonly utilised in healthcare area are positivist, postpositivist, interpretive, and critical social theory. Creswell (2009) proposed a conceptual framework of components for any research design and explained the interconnection among these components, as depicted in Figure 3.1.

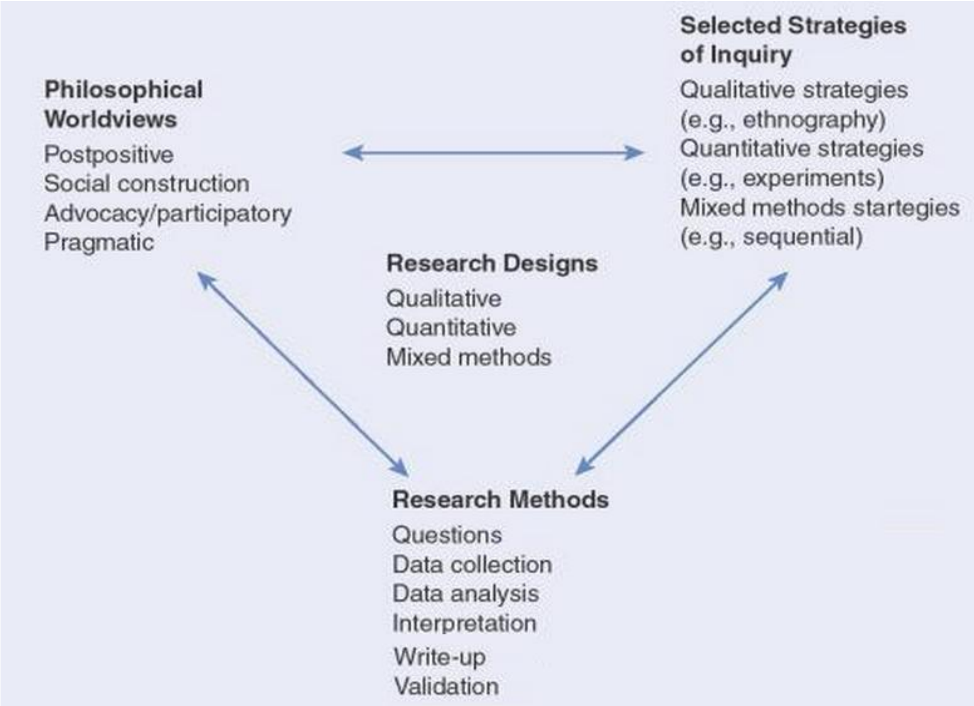


Figure 3.1: A Framework for Design-the Interconnection of Worldviews, Strategies of Inquiry, and Research Methods (Creswell, 2009)

In Figure 3.1, Creswell (2009) focused on three research approaches: quantitative, qualitative, and mixed methods. The first two have been available for decades, and the last is new and still developing in form and substance. A mixed methods approach, which involves a combination of quantitative and qualitative approaches, is increasingly recognized as a valuable method to address a research question, especially in healthcare services, because they can capitalize on the respective strengths of each approach (Curry, Nembhard, & Bradley, 2009). The following paragraphs include details of each research approach.

The quantitative research approach is described by the terms "empiricism" (Leach, 1990) and "positivism" (Duffy, 1985). This research approach is a formal, objective and deductive form of problem solving. It describes, tests, and examines cause-and-effect relationships (Burns & Grove, 2005) using a deductive process of knowledge attainment (Duffy, 1985). According to Davis (1997) and Gorman, Clayron, Rice-Lively and Gorman (1997), quantitative research focuses more on numerical or statistical data. Fitzpatrick, Secrist and Wright (1998) defined a quantitative technique as counting, scaling, and abstract reasoning. Furthermore, quantitative methods focus on the strict quantification of observations and typically incorporate large-scale sampling procedures and the use of statistical tests to study group averages and variables. Quantitative research also aims to determine the relationship between one item (an independent variable) and another (a dependent or outcome variable) in a population (Kopala & Suzuki, 1999). According to Neuman (2007) the techniques of data collection used in quantitative research to address a research question are experiments, surveys, content analyses, and existing statistics.

The qualitative research approach is a form of scientific inquiry that spans different disciplines, fields, and subject matters, and comprises a number of varied approaches (Denzin & Lincoln, 2005). Qualitative methods can be used to understand complex social processes, capture the essential aspects of a phenomenon from the perspective of study participants (Malterud, 2001), and uncover beliefs, values, and motivations that underlie individual health behaviours (Berkwits & Inui, 1998; Crabtree & Miller, 1999). Such research can also illuminate aspects of organizational context and healthcare delivery that influence organizational performance and the quality of care (Sofaer & Firminger, 2005). Qualitative studies are often exploratory in nature and seek to generate novel insights (Patton, 2002; Pope & Mays, 1995). Patton (2002) clarified that qualitative approaches are characterized by three types: "in-depth, open-ended interviews, direct observation, and written documents (including program records, and personal diaries or logs)." The strategies of qualitative research include grounded theory, ethnography, case study, and phenomenology. Each approach is uniquely suited for specific types of investigations, and the choice of design is determined by the aim of study. Davis (1997) stated that qualitative research provides an opportunity to "get close to the data," to see and hear respondents express their thoughts in their own words. This provides an opportunity to draw insights and explanations from the respondents themselves. Thus, the researcher does not have to pre-determine the areas of response or study importance. According to Patton (1990), qualitative methodologies provide avenues that can lead to the discovery of deeper levels of meaning.

The mixed methods approach is a combination of the quantitative research and the qualitative research (Bryman, 1988; Creswell, 1994). According to Creswell, Plano, Gutmann, and Hanson (2003, p.212), define this approach as "A mixed methods study involves the collection or analysis of both quantitative and/or qualitative data in a single study in which the data are collected concurrently or sequentially, are given priority, and involves the integration of the data at one or more stages in the process of research." Pairing the quantitative and qualitative components of a larger study can achieve various aims, including corroborating findings, generating more complete data, and using results from one method to enhance the insights obtained with the complementary method. Approaches to mixed methods studies differ based on the sequence in which the components occur and the emphasis given to each (Bryman, 2008; Creswell & Clark, 2007; Curry, et al., 2009).

3.3 Research Methods

A research method is a plan that helps the researcher to generate answers for the research questions (Burns, 2000). Thus, it weaves through the objectives, the research questions of the study, and the data gathered to the conclusions and recommendations drawn at the final stage of the study. Patton (1990) suggested that a combination of methodologies strengthens a research method, which means that both qualitative and quantitative types of research, as a mixed methods approach, provide complementary types of information.

To achieve the objectives of the current study, the researcher adopted the mixed methods approach. This method included both qualitative and quantitative techniques of collecting data. The use of both the techniques was necessary to encompass the different aspects of cooperation among physicians in sharing information and skills in the patient treatment within the hospital environment. According to Curry, Nembhard, and Bradley (2009), the combination of both qualitative and quantitative data collection, as a mixed methods approach, can be useful, especially in the healthcare services research. The philosophy behind this approach is that the systematic synthesis of different methods will compensate for some of the inherent weaknesses of the individual methods when applied alone (Curry, et al., 2009; Kopala & Suzuki, 1999). As a result, the strengths and weaknesses of qualitative and quantitative approaches can complement each other to achieve desired outcomes (Bryman, 2008; Creswell, Klassen, Clark, & Smith, 2011).

The quantitative approach of this study participates in its philosophical foundation with the positivist paradigm. Such paradigm emerged from the philosophy recognized as logical positivism and is based on rules of logic and measurement, truth, absolute principles and prediction (Weaver & Olson, 2006). The positivist philosophy debates that there is one objective reality (Neuman, 2007). Furthermore, the nature of this study is a case study research to investigate research objectives. This case study also needs capture the essential aspects of phenomenon from the perspective of study participants to deeper discover of meaning for developing adequate cooperative HISs model based on the user requirements. However, this type of research in healthcare services environment cannot fully address the research question by using the quantitative approach of data collection alone (Curry, et al., 2009). As a result, the qualitative approach is also incorporated into the research design.

The qualitative approach participates in its philosophical foundation with the interpretive paradigm. This type of paradigm reinforces the view that there are many truths and multiple realities. It also focuses the holistic perspective of the person and environment. Additionally, the interpretive paradigm is united more with methodological approaches that provide an opportunity for the voice, concerns and practices of research participants to be heard (Thorne, 2000; Weaver & Olson, 2006). Thorne (2000, p.68) further argues that qualitative researchers are "more concerned about uncovering knowledge about how people think and feel about the circumstances in which they find themselves than they are in making judgements about whether those thoughts and feelings are valid".

The researcher found it necessary to combine the quantitative (positivist paradigm) with the qualitative (interpretive paradigm) because of the complex nature of the research study. Also, there was no single paradigm that could sufficiently deal with all of the required methodological aspects. The mixing of both paradigms provided the researcher with the ability to analyze the scientific data of current levels of professional cooperation among physicians whilst also recognizing the significant factors that influence such cooperation among physicians. It also provided physicians' requirements in developing effective cooperative HISs environment.

According to Creswell et al. (2003), in the combination of quantitative and qualitative methods, researchers should consider the stage at which methods are integrated. The aforementioned authors also indicated that priority may be given to one method over another, or two methods may be given equal emphasis. To clarify how this study was conceptualized, Morgan's (1998) priority-sequence model as adapted from Morse (1991) was employed (see Figure 3.2).

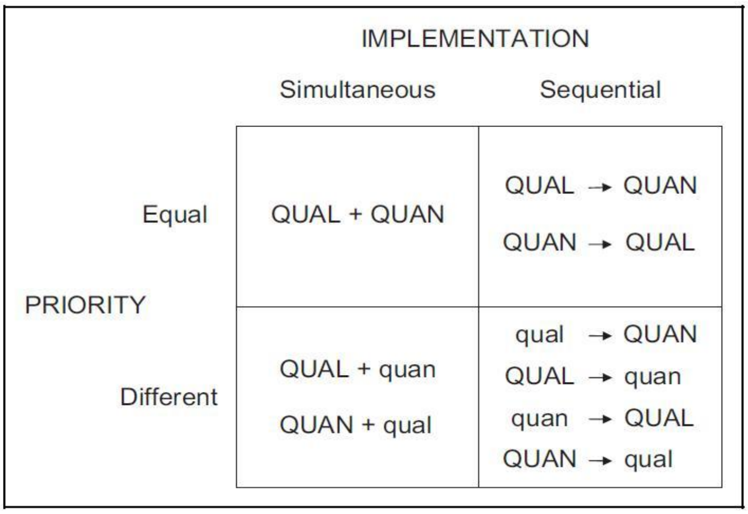


Figure 3.2 : Types of Mixed Methods Designs (Morgan, 1998)

Note: The main or dominant method appears in capital letters (QUAN, QUAL); the complementary method is in lowercase (quan, qual); + = simultaneous design; →= sequential design.

Figure 3.2 shows a general model that supports a mixed methods approach. The researcher was guided by this model in the process of determining priority. The researcher was able to choose the quantitative approach as the principal data collection method, which was believed to have the strength required to achieve the research goals. The contrasting complementary method (qualitative method) was chosen because it offered the strengths that were needed in the overall ability of the research design to meet the research goals. The main goal of the study was to maximize the value of the collected data; thus, the complementary method was made to follow the main data collection process. Therefore, the QUANT→qual sequence model, as shown in Figure 3.2, guided the researcher in the data collection procedure, data analysis, and discussion of findings. The discussion that follows will further elaborate and describe in detail how a methodological approach was designed and implemented in this study.

3.3.1 Research Design

In this research as case study, qualitative and quantitative data collection techniques were used including; questionnaires and semi-structured interviews. Additionally, to provide a more complete and multidimensional understanding of the issues, a complementary methodology design was employed as the QUANT→qual sequence model (see Figure 3.2).

In this study, questionnaires and semi-structured interviews were employed in two stages. In the first stage, as empirical data collection, both techniques (see Appendix A and B) were employed sequentially, in a complementary fashion (Bryman, 2008), to ask subjects to determine the levels of cooperation among physicians in sharing information and skills in patient treatment, to determine the factors affecting such cooperation in two government hospitals in Kurdistan region of Iraq as case study, and determine how R&D unit activities affect cooperation among hospital physicians. Furthermore, this study was intended to develop a proposed FHIS model (see Figure 2.13 in Chapter 2) to improve cooperation among physicians in the hospital environment based on the participants' requirements. Based on that in the second stage, questionnaires and semi-structured interviews (see Appendix C and D) were employed also sequentially to evaluate the proposed FHIS model, as pre-implementation and post-implementation of the system. This evaluation process involved testing the usability of FHIS system and determination the extent to which such a system improves cooperation among physicians with regard to the sharing of information and skills in patient treatment in the hospital environment. Figure 3.3 extracted the aforementioned two stages of data collection in this study as a methodology flow chart.

Figure 3.3 shows the methodology flow chart done for this study. This methodology includes two stages (stage I and stage Π) of data collection. The stage I begins with the development of questionnaire and semi-structured interview instruments to collect empirical data to address the study objectives and develop a proposed FHIS model based on the physicians' requirements. The stage Π tries to evaluate the FHIS to investigate the study aim. The following sections are detailed the previous two stages.

Stage I	Stage П
Data collection instruments for empirical data: Questionnaire & semi-structured interview questions development • Validity testing • Reliability testing Data collection and analysis model (QUANT→qual) Case study: • Hospital A • Hospital B Population: • Physicians (e.g. hospital managers, doctors, senior house officers, intervention cardiologists and cardiac surgeons) Sample size: • Purposive sample (physicians who work in care units related to the cardiac centre in each hospital)	Data collection instruments for evaluation the FHIS system: Questionnaires Semi-structured interviews Data collection and analysis model (QUANT→qual) Case study: (same hospitals (stage I)) • Hospital A • Hospital B Population: (same population (stage I)) • Physicians Sample size: (same purposive sample (stage I)) • Purposive sample (physicians whose actually used the FHIS system)

Figure 3.3: Methodology Flow Chart

3.3.2 Case Study

According to Davies and Beaumont (2007), the case study is a method that enables a researcher to learn and analyze a real situation and to develop a solution by applying theoretical concepts, experience, and observation by focusing on the conceptual issues of a case study. Moreover, through the case study, a researcher faces new problems that they might never have experienced before. The strength of a case study involves a detailed and holistic investigation of the conducted units. The researcher is not limited to any research method or instrument. Furthermore, the data collection of case studies can be conducted over a certain period. However, one of the main weaknesses of the case studies is related to the analysis of small data sets, such as one unit (i.e., a hospital), which may result in limited insights into relevant subjects. Therefore, having different units (i.e., hospitals) of case studies to cover multiple aspects and providing more evidence of relevant issues is useful (Leary, 2012).

As mentioned, this study aims to propose and develop a Fractal-based Healthcare Information System (FHIS) model to provide an integrated cooperative HIS environment. Such a model is intended to improve cooperation among physicians in sharing information and skills in patient treatment in the same and in different hospitals to enhance the physician’s skills and healthcare services. The FHIS model also involves multiple units (i.e., several hospitals) connected as fractal units, because this study requires more than one hospital to consider as subject to address the issue of cooperation among physicians in sharing information.

In this study, only two remote government hospitals (Hospital A and Hospital B) are used as case studies due to the availability of cardiac centres in such hospitals. Table 3.1 and Figure 3.4 illustrate their locations. The profile, HIS and activities of Hospital A and Hospital B as well as the professional cooperation among physicians of each hospital are detailed in Chapter 4.

Table 3.1 : Hospital Locations

The Federal Region	**City**	**Hospital**
Kurdistan Region/Iraq	Duhok	Hospital A
	Erbil	Hospital B

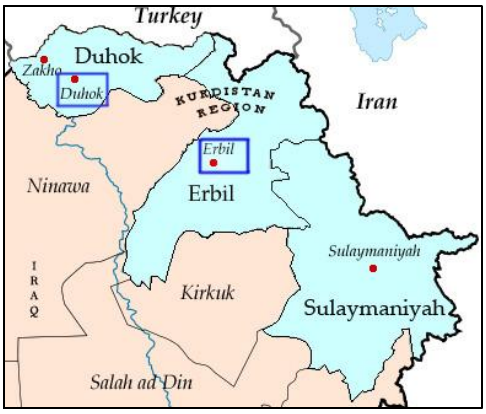


Figure 3.4: Kurdistan Region Map of Iraq

The aforementioned hospitals were selected as subjects of this study for several reasons. First, deterioration in services and unsafe movement between cities have occurred following the 2003 invasion of Iraq (Ali, et al., 2011; Burnham, et al., 2012). Second, interest in the development of healthcare facilities and safe movement between cities in the federal region of Kurdistan is considerable. Third, difficulty exists in connecting government and private hospitals because health services in government hospitals are provided free to the country's residents (Heshmati & Darwesh, 2007). Fourth, selected hospitals have cardiac centres because heart disease is a major health problem in Kurdistan region, as the Ministry of Health in this region noted (Kurdistan Regional Government, 2007). However, these cardiac centres are limited in number and became available in Kurdistan region after 2007 (Kurdistan Regional Government, 2007). Furthermore, the skills and experiences among local surgeons and cardiologists in the region are lacking (Burnham, et al., 2012; Custer, 2009). Thus, the physicians in cardiac centres have to cooperate with other physicians to improve their skills and enhance their ability to provide excellent medical services to citizens (Kurdistan Regional Government, 2007).

3.3.3 Population

Given the focus of this study on the issue of cooperation among physicians in sharing information and skills in patient treatment, the population comprised 100 physicians. They included hospital managers, doctors, senior house officers, intervention cardiologists, and cardiac surgeons. All of them were involved in care units related to a cardiac centre. These physicians were drawn from two remote government hospitals, Hospital A and Hospital B in Kurdistan region, as case studies (see Table 3.1). The population profile is tabulated in Table 3.2.

Furthermore, considering the difficulty of studying whole healthcare information systems (HISs) in a hospital, the cardiac centre has been selected as a model for studying the entire HISs. In addition, the hospital involves a large number of units; thus, connections between their information systems are complex, and their establishment requires time (Al-khawlani, 2009; Yang, Liu, et al., 2009; Masaud-Wahaishi & Ghenniwa, 2009). The following subsection is detailed the selection of sample for this study.

Table 3.2: The Population Profile

Hospital Name	**Hospital Specialization**	**Physicians**	**Physicians number**	**Cardiac Centre Units**
Hospital A	- General hospital - Teaching hospital	- Hospital manager - Doctors - Senior house officers - intervention cardiologists - cardiac surgeons	80 physicians (10-15 intervention cardiologists and cardiac surgeons) *Note: this number of physicians in change	- Consultation - Cardiac Catheterization - Echo - ECG - Lab Investigations - Exercise - CCU - Cardiac Surgery (has opened in 2012)
Hospital B	- Cardiology hospital - Teaching hospital	- Hospital manager - Senior house officers - intervention cardiologists - cardiac surgeons	20-30 physicians *Note: this number of physicians in change	- Emergency - Consultation - Cardiac Catheterization - Echo - ECG - Lab Investigations - Exercise - CCU - Cardiac Surgery

3.3.3.1 Selection of Sample

In this study, the samples of participants consisted of physicians, the selection of whom was based on purposive sampling that involves selecting particular units or cases (Teddlie & Yu, 2007). According to Leary (2012), in the purposive sampling, researchers can decide which participants include in the sample. As mentioned, a sample of physicians from two government hospitals in the federal region of Kurdistan, Iraq was selected as a case study. Kurdistan region was chosen because of reasons mentioned previously (see section 3.3.2). In addition, the selection of the sample focused on physicians who work in care units related to the cardiac centre in each hospital.

The survey sample for empirical data comprised a total of 100 participants. The researcher attempted to cover all physicians in those two hospitals. They included hospital managers, doctors, senior house officers, intervention cardiologists, and cardiac surgeons (see Table 3.2). The questionnaire technique was used to collect quantitative data from the survey sample. The questionnaires were personally handed to the respondents (i.e., physicians). Among the 100 questionnaires distributed, 81% were fully completed and included for analysis after excluding the incomplete questionnaires. Table 3.3 shows the number of physicians who participated from each hospital.

Table 3.3 : Number and Distribution of Questionnaires Completed

Hospital Name	**Distributed Questionnaires**	**Received Questionnaires**	**Completed Questionnaires**	**Incomplete Questionnaires**
Hospital A	80	72	65	7
Hospital B	20	18	16	2
Total	100	90	81	9

For the qualitative data collection of empirical data, samples of in-depth interviews were conducted with 10 specialist physicians, including cardiac centre managers, intervention cardiologists, and cardiac surgeons from selected hospitals for this study. Only 10 specialist physicians participated in interviews; some of the physicians refused to participate, and others were on vacation during the data collection period. Table 3.4 shows the number of specialist physicians and their profiles who participated from each hospital.

Table 3.4: Number of Interviews Conducted and their Profiles

Hospital Name	Number of Specialist Physicians	Interviewee Profile	Code of Interviewee	Gender	Educational Qualification	Date, Time
Hospital A	6 (Specialist physicians in cardiologist) 6 (Specialist Physicians interviewed)	Interventional Cardiology	APY1	Male	PhD in Interventional Cardiology	13/11/2009 11:00 am - 1:00 pm
		Manager of Cardiac Centre	APY2	Male	PhD in Cardiologist	19/11/2009 11:30 am - 12:30 pm
		Cardiologist	APY3	Male	PhD in Cardiologist	22/11/2009 12:00 pm - 1:00 pm
		Cardiologist	APY4	Male	PhD in Cardiologist	23/11/2009 12:00 pm - 1:00 pm
		Cardiac Surgeon	APY5	Male	PhD in Cardio Thoracic & Vascular Surgery	26/11/2009 8:00 pm - 9:30 pm
		Interventional Cardiologist	APY6	Male	PhD in Interventional Cardiologist	27/11/2009 12:00 pm - 1:30 pm
Hospital B	9 (Specialist physicians in cardiologist) 4 (Specialist Physicians interviewed)	Cardiac Surgery	BPY1	Male	PhD in Cardiac Surgery	16/11/2009 10:30 am - 11:30 am
		Consultant physician & Cardiologist	BPY2	Male	PhD in Cardiologist	17/11/2009 10:00 am - 11:00 am
		Manager of the hospital	BPY3	Male	PhD or D.M. (Doctor of Medicine)	17/11/2009 12:00 pm - 1:00 pm
		Internist	BPY4	Male	PhD in progress in Internist	18/11/2009 8:00 pm - 9:30 pm
Number of Interviews Conducted			Only 10 Specialist Physicians from both hospitals			

3.3.4 Data Collection Instruments of Stage I

In stage I of data collection of this study, data were primarily collected through questionnaire and semi-structured interview instruments. The questionnaire instrument was used as a survey method to easily collect quantitative data from respondents. The main advantages of the questionnaire research instrument as agreed upon by Neuman (2007) and Bryman (2008) were that relatively low costs were involved in the development, design, and use of instruments in the data collection process. Second, the instrument was used with minimal assistance and facilities; thus, it was easier for respondents to answer. Finally, the use of the survey instrument was convenient because it gave respondents sufficient time to provide thoughtful answers, look up records, or consult with others. In comparison, interview instrument was considerably more interactive and allowed the researcher to clarify questions for the respondents and obtain valuable qualitative data from them (Bryman, 2008; Kaplan, Truex, & Wastell, 2004). This procedure of data collection helped the researcher to clarify in-depth information and to extract the requirements needed for developing the proposed FHIS model. The empirical data were collected between October and December 2009 from both case studies (Hospital A and Hospital B) concurrently (see Figure 3.3).

To compile, design, and develop data collection instruments of this study (i.e., questionnaires and semi-structured interviews), a careful process of collecting and gathering the required information was carried out in a number of ways. On the one hand, the research instruments were constructed after a thorough review of the available published literature, such as Samuel (2009), Shahmoradi et al. (2007), Raddy and Jansen (2008), and Al-Ta'e (2009), consultation with local experienced physicians and reflection upon the researcher's knowledge and professional experience. On the other hand, the researcher conducted a thorough literature review to familiarize himself with the conceptual foundations. Unfortunately, most of the prior researchers in the literature review, such as Collins et al. (2011), Gotoh et al. (2005), Li and Yao (2006), Reddy and Jansen (2008), Sadreddini (2003), Yang, Liu et al. (2009), Yang, Qin et al. (2008), addressed the issue of cooperation among physicians in sharing information using qualitative instruments. This indicated that no previously tested questionnaire was available for this research study; therefore, the researcher was required to develop and validate the questionnaires before their use. Furthermore, the research instruments were then tested to evaluate their validity and reliability through expert validation and face validation followed by a pilot test (Best & Kahn, 2006; Bryman, 2008; Odeh, 1999).

Initially, ethical approval from the Research Ethics Committee of Health of Directorate General of Health, Duhok Governorate, Ministry of Health, Kurdistan region of Iraq, was obtained before any information was gathered from any of the hospitals selected as the case study. Through a written letter and personal visits, the researcher informed the health directors and hospital managers about the upcoming study. Official permission was obtained from the health directors and the hospital managers. The letters of approval are shown in Appendix E. The researcher also used the same opportunity to explain the purpose of the study to the hospital managers. At the same time, the hospital managers were requested to explain the aims of the study to their staff members, especially those who were enlisted to participate in the study, based on the guidelines provided by the researcher.

3.3.4.1 Questionnaire

A structured questionnaire was developed covering topics such as the current levels of professional cooperation among physicians in sharing information and skills in patient treatment within the hospital environment, significant factors affecting such cooperation among physicians, the role of R&D unit activities in the hospital, and the requirements for developing an FHIS model to improve cooperation among physicians. The researcher was confronted with two major issues when developing the questionnaire instrument. Firstly, the researcher needed to develop a tool that would accurately assess the current levels of professional cooperation among physicians as mentioned previously in this section. Secondly, the researcher needed the tool to determine the role of R&D unit activities within the hospital environment. These two important and fundamental characteristics of a measurement tool (validity and reliability) need to be proven before its use. The final version of the questionnaire (included in Appendix A) consisted of five main sections:

1. Section A contained demographic information about the respondents, specifically, name (optional), name and address of the hospital, contact information (optional), gender, and educational qualifications. Generally, this section contained at least six items.
2. Section B contained background information related to the HIS in the hospital. This section contained 16 items of structured questions that were answerable by "Yes" or "No" as a measuring scale. In this section, information about the problems and needs of a healthcare system environment were extracted from the respondents' answers.
3. Section C was about professional cooperation among physicians. This section contained nine types of cooperation with responses provided on a five-point Likert scale. Respondents were asked to rate their opinion on their cooperation with regard to each of the previous types on a scale of 1 (No cooperation) to 5 (Very good cooperation). The section aimed to determine the current levels of cooperation among physicians in sharing information and skills in patient treatment within the hospital environment.
4. Section D was about the work of the R&D unit in the hospital environment. This section contained nine statements on the role of R&D unit activities in the hospital with responses provided on a five-point Likert scale. Respondents were asked to rate their opinion on the work of the R&D unit within the hospital environment with regard to each of the previous statements on a scale of 1 (Strongly disagree) to 5 (Strongly agree). The section aimed to determine how the role of the R&D unit affected cooperation among physicians in the hospital environment. In addition, statements 7 and 8 of the same section revealed the weak activities of the R&D unit within the hospital environment, whereas statements 4 and 5 were adapted as the fractal-based system.

5. Section E contained five open-ended questions, which asked the respondents to express their ideas, opinions, and suggestions about the methods used for enhancing healthcare services in the hospital, to give some reasons that affect the cooperation among physicians in terms of sharing of skills in the hospital, to provide some suggestions about improving physicians' skills in the hospital, and to suggest some obstacles encountered in the integration of a database system for the R&D unit activities in the hospital, as well as to determine the current types of healthcare services given to patients in the hospital.

In most cases, the researcher handed the questionnaire directly to the participants. Data analysis of the questionnaires was performed using the Statistical Package for the Social Sciences (SPSS). Likert scales, descriptive statistics (e.g., percentage, means, and standard deviations) were used to describe the basic features of collected data. A simple regression analysis was conducted to identify the effectiveness of R&D unit activities on professional cooperation among physicians in the hospital environment. Qualitative data from open-ended questions in the suggestions section of the questionnaire were analyzed using narrative analysis as content analysis process (Suter, 2011). In this process, the main and emerging ideas were recognized in several readings of the data. Certain words and phrases that repeatedly appeared emerged from the data.

3.3.4.2 Interviews

In addition to administering questionnaires, the researcher investigated the research topic in a more detailed manner by conducting the in-depth interviews with 10 specialist physicians, including cardiac centre managers, intervention cardiologists, and cardiac surgeons from the selected hospitals. In Hospital A, six specialist physicians, including the manager of the cardiac centre, were interviewed. In Hospital B, four specialist physicians including the manager were interviewed (see Table 3.4). The research instrument of in-depth interviews was useful in studying issues in a more in-depth manner than in the research instrument of questionnaires.

All of the interviews were conducted by the researcher to maintain consistency of responses. The researcher used a guide in conducting the interviews. The interview guide was developed set of interview questions. These questions were developed based on the objectives of the study (see Appendix B). The open-ended questions used during the interview process were based on recommendations from existing literature, anecdotal information, and conversations with the researcher's expert cardiology colleagues (Bryman, 2008). Overall, 25 questions were asked during the interviews, and each interview session took approximately one to two hours. The Kurdish, Arabic, and English languages were used in the interviews. The interviews continued until data saturation was achieved (i.e., no new opinions were raised) (Bryman, 2008). With the permission of the physicians, data were recorded, written, and summarized. These data were then translated into English, transcribed, and analyzed based on themes (Miles & Huberman, 1994). The transcription process involved transferring the recorded interview files from the voice recorder to the personal computer of the researcher. This procedure was followed by the word-by-word transcription of the interviewee data. The transcription process was then followed by the subsequent data reduction in an Excel format. In this context, the issues were classified based on the codes of the physicians, as shown in Table 3.4. This approach helped the researcher to sort the data easily, transcribe, and display the data in accordance with themes depending on the objectives of the study. The results of in-depth interviews are presented in Appendix B.

3.3.4.3 Validity of Instruments

To ensure that the items developed in both the research instruments (questionnaire and interview guide) were reasonably appropriate, the instruments were tested for validity and reliability. In this regard, validity addresses the issue of whether what we attempted to measure was actually measured. One type of validity is face validity, which is concerned with whether or not a test looks as if it measures what it is supposed to measure (Bryman, 2008). Validity assesses whether the test measures what it claims to measure (Burns, 2000). Thus, validity is concerned with the extent to which an indicator accurately measures the concept (Best & Kahn, 2006). According to Bernard (2000), validity is a crucial element in research because it addresses the accuracy and trustworthiness of instruments, data, and findings.

Meanwhile, content validity is achieved when an instrument has appropriate content for measuring a complex concept or construct (Bernard, 2000). The research instruments of this study were revised and sent to selected professionals in the area of study to check the validity of the instruments. The professionals were able to validate the instrument for face validity before conducting the pilot study. They were also helpful in evaluating the appropriateness of the contents of the research instruments.

The professionals selected for this purpose were two specialist physicians from cardiac centre of the Hospital A. Additionally, three lecturers from the Faculty of Science and the Faculty of Medical Science of the University A in Kurdistan region, Iraq, and two lecturers from the Faculty of Computer Science and Information Technology of the University of Malaya in Kuala Lumpur, Malaysia were included in the process. They were chosen based on their sound knowledge in this field, and were considered to possess the insight to evaluate the instruments of this study.

The aforementioned professionals were requested to provide their inputs and suggestions as they felt necessary for accuracy and content validity of the instruments. These professionals were all handed copies of the instruments and an information sheet explaining the purpose of the study. All of them were provided comments on items of the instruments. The researcher believed that the input of ideas from these professionals significantly contributed to the success of the instrument design based on their comments.

3.3.4.4 Reliability of Instruments

Reliability of instruments directs to the consistency of a measure of a concept to consider whether a measure is reliable. Reliability addresses the ability of a measuring tool to provide the same result on repeated occasions. One ways of leading this is the test-retest method. This method addresses the question of consistent answers from multiple occasions of use (Bryman, 2008).

To address the issue of questionnaire reliability in this study, the test re-test method of reliability testing was used. According to Robson (2002), researchers studying fixed design should conduct a pilot study to sort out any technical issues in the data collection method. In this study, the data were collected through a composite survey instrument. The research questions in this study examined two macro variables, namely, the professional cooperation among physicians, and the work of the R&D unit. Each of these macro variables was measured by a set of specific questions. The variables were measured using five-point Likert scales. The intent of the field test was to analyze the operational aspects of the questionnaire, such as content and flow, question ambiguity, completion time, and the reliability and validity of the questions.

The validity is related to accuracy and whether the operationalization of a variable correctly represents what it is supposed to represent. Internal validity is one of the main considerations in this study. According to Bryman (2008), this type of validity is "concerned with the question of whether a conclusion that incorporates a causal relationship between two or more variables holds water." It means that the factor that has a causal impact is an independent variable, as the work of the R&D unit, and the effect is a dependent variable, as the professional cooperation among physicians. Reliability is related to consistency; it refers to the expectation that the findings will not vary each time the measures are used, assuming that nothing has changed in what is being measured (Hoskins & Mariano, 2004; Neuman, 2007; VanderStoep & Johnston, 2009).

In this study, a pilot test was conducted to determine the validity and reliability of the composite measure. This field test used a sample consisting of nine members from the proposed study population. The distribution and collection of the questionnaires were personally administered by the researcher to ensure a 100% response rate. The field test participants completed the questionnaire. Their comments and suggestions, along with data analysis, were incorporated to improve the questionnaire. Given that a field test was conducted and the questionnaire was developed specifically for this study, only face validity was assessed, and scale reliability was measured with the Cronbach's alpha coefficient; moreover, items were removed as deemed necessary to purify the scales, as shown in Table 3.5.

Table 3.5 : Coefficient Alphas of Scale for Study Variables (N=9)

Variables	**Items**	**Cronbach's Alpha**
The professional cooperation among physicians	9	.85
The work of research and development unit	9	.83

The information in Table 3.5 indicates the interval scale variables that were used in this study. The entire variable shows a high internal reliability value ranging from 0.83 to 0.85. The reliabilities presented in Table 3.5 suggest that the indicators are sufficient for use because the values are higher than the reliability indicator provided by Nunnaly (1978).

The reliability of open-ended questions used during the interview process was achieved through asking of the same questions for each interviewer. According to Leary (2012), the higher reliability can be achieved in the interview by asking questions as they worded to all respondents.

3.3.5 Data Collection Instruments of Stage Π

In the stage Π of this study (see Figure 3.3), a combination of quantitative and qualitative approaches was used sequentially in a complimentary fashion, as a mixed method, to collect data and measure the goals of the study. This mixed methods approach was utilized to evaluate a proposed FHIS model and was used mainly to answer a research question (i.e., To what extent does the FHIS model improve cooperation among physicians with regard to sharing information and skills?). According to Al-Yaseen, Al-Jaghoub, Al-Shorbaji and Salim (2010), and Mbananga, Madale and Becker (2002), in the HIS, particularly in the evaluation process, the projects required substantial investments to predict the impact of the outcomes of such systems in the real domain. The HIS evaluation process might include both the quantitative and qualitative data collection approaches. Taking each approach alone would lead to the investigation of a partial picture of the study, but taking both approaches together would lead to the investigation of the entire picture of the study (Anderson & Aydin, 2005; Cusack et al., 2009).

According to Kaipio (2011), the evaluation of system usability in HISs becomes a key process in implementing such systems. The system usability goals specify the target values for effectiveness, efficiency, and user satisfaction in the use of the system (Ng, Lo, & Chan, 2011). Given that the evaluation of system usability is an important process in the post-implementation of the system, this study covers this issue to measure the system’s effectiveness, efficiency, and user satisfaction.

In the evaluation stage, the survey questionnaire and semi-structured interview instruments were used to evaluate the system. Participant samples were selected from the same population of the two selected hospitals (Hospital A and Hospital B) that actually used the system. There were 56 respondents to the questionnaire, and in-depth interviews were conducted with 10 specialist physicians from those two hospitals.

3.3.5.1 Questionnaire

A questionnaire was used (1) to evaluate the usability of the FHIS by physicians, (2) to evaluate the extent to which the FHIS improves the level of cooperation among physicians with regard to the sharing of information and skills in patient treatment within the hospital environment, and (3) to provide comments on the usefulness and relevance of the FHIS with regard to professional cooperation among physicians. Therefore, this questionnaire (included in the Appendix C) was divided into three sections:

1. Section A of the research instrument is about the system usability of effectiveness, efficiency, and satisfaction from the viewpoint of physicians. In this section, the system usability was measured using the System Usability Scale (SUS) tool (Brooke, 1996). The SUS was a free, easy, and effective tool for assessing the usability of any system (Bangor, Kortum, & Miller, 2009; Ng, et al., 2011). According to Bangor, Kortum and Miller (2008), this tool has also been found to be a good choice for the usability of any system, among others. In terms of reliability, multiple studies, such as Bangor et al. (2009), and Lewis and Sauro (2009) have found the SUS to have a Cronbach's alpha of 0.85 and above (i.e., values above 0.70 are considered "good") (Nunnally, 1978). The SUS was a simple, 10-item scale that provides a global view of subjective assessments of usability, which is calculated based on the survey results. The SUS scores in this

study were shown in Chapter 6 in a 100.00 scale, which indicates the higher level of effectiveness, efficiency, and satisfaction in the use of the system.

2. Section B is about professional cooperation among physicians, which is the same as Section C of the questionnaire used in the first stage (Stage I) of this study (see section 3.3.4.1). Due to the long time period between the initial data collection (Stage I) and implementation of the system, and the continuous change in the number of doctors in both participated hospitals (Hospital A and Hospital B), this section of the questionnaire was distributed twice in the pre-implementation and post-implementation of the FHIS. It aimed to determine the level of cooperation among physicians in sharing information and skills in patient treatment within the hospital environment before and after the implementation of the FHIS. The same participant samples were selected for pre-implementation and post-implementation of the FHIS. A paired samples T test was conducted with SPSS software to compare the mean test scores before (pre-test) and after (post-test) the system implementation. This study intended to see the improvement in the levels of cooperation among physicians in the hospital environment. The results are detailed in Chapter 6.
3. Section C presents the participants' comments on the usefulness and relevance of the FHIS in relation to the professional cooperation among physicians. Other questions were intended to gather suggestions on the strengths and weaknesses of the FHIS in relation to cooperation among physicians in the hospital environment to consider such suggestions to further improve the performance of the FHIS.

3.3.5.2 Interviews

A qualitative approach to data collection (i.e., a semi-structured interview instrument) was used to add another important dimension to the evaluation study. It allowed evaluators to understand how physicians interact with the new system. The open-ended questions used during the interview process were based on recommendations from existing literature and anecdotal information. This instrument often generated anecdotes and stories that resonated with the interviewees (Bryman, 2008). In the interview process the same questions asked to all interviewees to increase the reliability of data collection (Leary, 2012). Aside from the questionnaire, this instrument was used to complement the research questions and gather in-depth content. With the permission of interviewees, data were recorded, written, and summarized. These interviews were later translated and transcribed, and then analyzed using a coding process, as shown in Appendix D.

3.4 Development of the FHIS System

System development is the methodology of developing a system based on measures and rules (Davis & Yen, 1998). In this study, the FHIS model (see Figure 2.13 in Chapter 2) is proposed to provide an integrated cooperative HIS environment to improve cooperation among physicians in sharing information and skills in patient treatment. Such a model is developed based on the Fractal theory and its features to link system units as a fractal-based system. The FHIS was selected by the researcher because it is more open, autonomic, flexible, and cooperative than conventional systems (Leitão & Restivo, 1999). Such a system consisted of decentralized and autonomous process units that retrieve and update data to provide the necessary knowledge and information (Kirikova, 2008; Tharumarajah, et al., 1998; Warnecke, 1993). The units of FHIS involve same modules. The functions of these modules are detailed later in Chapter 6.

The development of the FHIS was all the work of the researcher but followed the classical strategy that provided by Kit (1995). This process started from design, testing and implementing of the FHIS followed by the evaluating process (see section 6.2 in

Chapter 6). Hence, the FHIS structure was developed on the basis of an agent-based technique, (see section 2.5.3 in chapter 2), to link the FHIS units in different hospitals as fractal units using Web-based application tools. These application tools were the Oracle database, Oracle JDeveloper, and Oracle Application Development Framework (ADF). Such applications were used because they have many tools to provide everything necessary to implement Web-based information sharing and to provide a flexible updating environment for the implementation, such as HTML, SQL, PL/SQL, Java, CSS, and BI publisher tools (Koletzke & Mills, 2007). Such a system can run on any computer with an RAM of one or more gigabytes, and can run on Microsoft Windows (e.g., XP and Server) or Linux.

The functional requirements for the FHIS are based on the operations of fractal features and also based on the physicians' requirements. These requirements of physicians are presented in Chapter 5 of this study. Aside from the functional requirements, other requirements have to be considered, such as the integrity, security, flexibility, and maintainability of the system. The operations of fractal features and other requirements in the FHIS are explained in Chapter 6.

The FHIS was initially put through a testing procedure, and then evaluated by potential users. The testing was necessary to control the quality of the system and determine whether the system can handle real applications. The primary purpose of testing was to ensure that the program and its resulting components fulfilled the requirements specification and eliminated the errors (Kit, 1995). Then, the evaluation of FHIS carried out by using the aforementioned instruments (see section 3.3.5). The testing and evaluation of FHIS were detailed later in Chapter 6.

3.5 Summary

This chapter has discussed the research design that was adopted to accomplish the research effort and address the research question in two stages. In the first stage, this study employed a mixed model research design integrating quantitative and qualitative approaches using a questionnaire survey that included both open-ended and closed-ended questions. These 100 questionnaires were distributed among physicians from the selected population for this study. In addition, in-depth interviews with 10 specialist physicians were conducted.

The development of the proposed FHIS model was outlined. The second stage was about the evaluation of FHIS using a questionnaire survey (i.e., 56 participants) and an in-depth interview (i.e., 10 participants) to investigate the research goal.

The reasons for using the aforementioned instruments are outlined, and their reliability and validity are explained. The empirical survey, evaluation survey, insight into the data coding process, overviews on the quantitative and qualitative methods of data analysis employed in the study are also highlighted in this chapter.

The summary of the research design as undertaken in the study is presented in Figure 3.5. The case studies (Hospital A and Hospital B) used in this research are detailed in the next chapter.

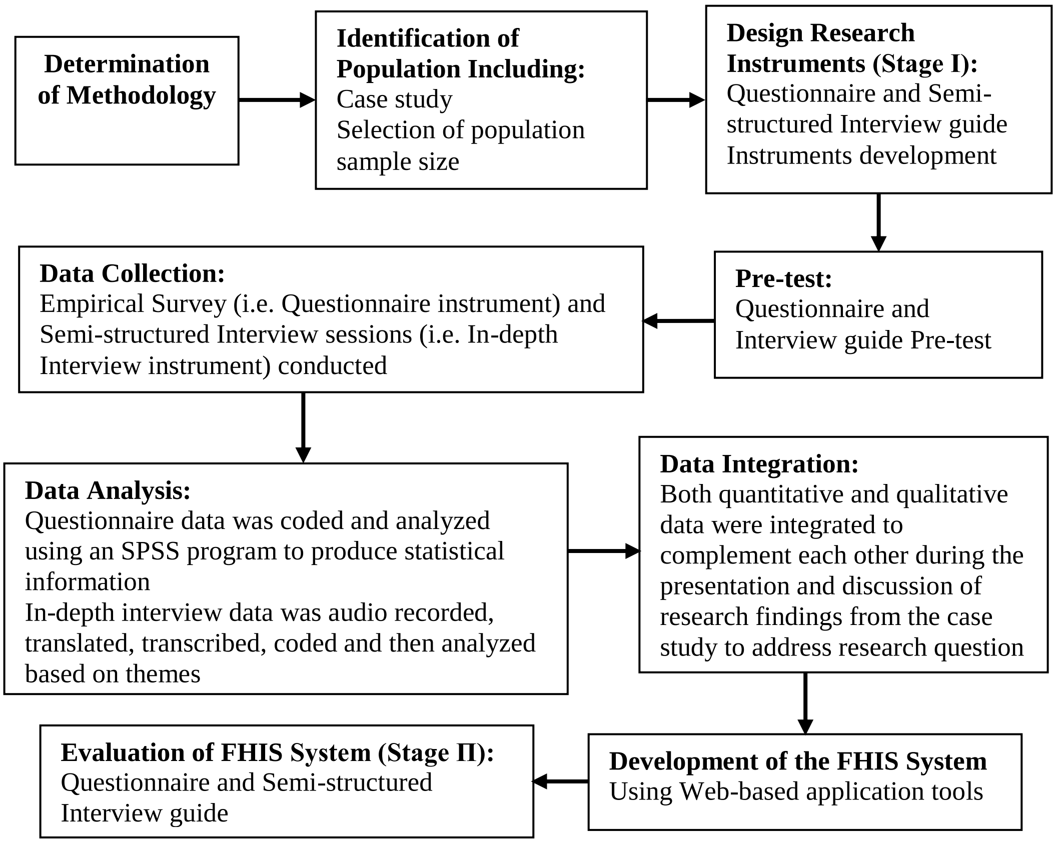


Figure 3.5: Summary of the Research Design

CHAPTER 4

THE CASE STUDIES OF RESEARCH

4.1 Introduction

Two remote government hospitals in Kurdistan region of Iraq are selected as case studies to address the research question, develop a FHIS system, and find convenient solutions for the research problem. These hospitals are from Duhok city (Hospital A) and from Erbil city (Hospital B).

This chapter begins with a description of each participant hospital. This description follows in-depth details related to the HIS used in each hospital, the activities of hospital and the professional cooperation among physicians in sharing information and skills in the patient treatment within the hospital environment. Furthermore, during the data collection period, the researcher participated in the daily work in both hospitals to observe what physicians do in the process of patient treatment. The next sections detail each hospital alone as case study to investigate the information relevant to the research objective.

4.2 Case Study 1 (Hospital A)

This case study, which was conducted in the Hospital A, focused on the systems used for managing and controlling healthcare information, such as patients' information and treatment, and physicians' information and schedules. Furthermore, this case study is about determining the activities used to improve the quality of healthcare in the hospital, such as physicians' activities in the patient treatment and the ways of professional cooperation among physicians in the hospital environment.

The Hospital A is the only general hospital in Duhok city at present. It was constructed by Marubeni, a Japanese company, in 1984. The general departments of this hospital are

Cardiology, Internal Medicine, Emergency Medicine, Surgery, Gynecology and Obstetrics, Psychiatric, Radiology, Laboratory, Administrative, and Technical. This hospital provides 490 beds for its patients. The Hospital A building has eight floors and several accessories around the hospital in different distances. The first floor contains the CCU unit (with 10 beds), the ICU (with four beds), and the cardiology ward as well as five operating theatres. The second floor contains the gynecology department, including delivery rooms and two emergency theatre rooms as well as a premature unit. The general surgery ward is on the third flour. The fourth floor has the internal medicine ward. The fifth floor consists of the urology ward (in the south wing) and the ENT and ophthalmology ward (in the north wing). The sixth floor contains the burn unit (in the south wing) and the gynecology ward (in the north wing). On the ground floor, the radiology department, laboratory department and physiotherapy unit, medical emergency unit, and two theatres for gynecology, consultation clinics for surgery, medicine, urology, cardiology, ENT, ophthalmology, infertility, plastic, and oncology are located. There is also an underground floor that contains the washing and laundry unit in addition to the kitchen and the restaurant. The Hospital A has over 742 staff members, including physicians, surgeons, credentialed allied health professionals, nurses, technicians, associate employees, and administrative staff. This hospital provides a number of healthcare services for general patients, including those who have heart diseases.

In 2007, the cardiac centre opened in the Hospital A, but it was incomplete. This centre has several related units from this general hospital. These units are CCU, Consultation, Cardiac Catheterization, Echocardiogram (Echo), Electrocardiogram (ECG), Lab Investigations and Exercise. Over 80 of physicians are working in the units related to the cardiac centre, including doctors, senior house officers, intervention cardiologists, and cardiac surgeons. However, the number of intervention cardiologists and surgeons of the cardiac centre in Hospital A is between 10 and 15. This number changes every year due to a program of changing physicians between this hospital and those from government hospitals in Kurdistan region and Iraq. Moreover, in 2012, the cardiac surgery unit has opened in the cardiac centre of Hospital A. Then, this follows aggregating all units related to cardiac centre under complete cardiac centre in the Hospital A in Duhok city. This centre also becomes the second complete cardiac centre in Kurdistan region after Hospital B in Erbil city. Currently, the cardiac centre of Hospital A provides 48 beds for heart patients. The centre provides various healthcare services, which are detailed in the following subsections.

4.2.1 HIS in the Hospital A

The Hospital A lacks a computer-based HIS, which means that healthcare recordkeeping is mainly based on a manual system. This kind of HIS results in difficult data analysis and the slow flow of information (World Health Organization, 2006).

The manual HIS in the Hospital A is used to manage only the inpatient information, including personal details, diagnosis, and treatment. The medical staff uses standard forms of medical reports. Each unit in the hospital has its own type of medical report. Sometimes these units keep a hard copy of the patient medical report, or a soft copy in Microsoft Word and Excel. The samples of these medical reports are shown in Appendix F. However, most of the patient information in the HIS of the Hospital A hospital keeps only one copy. Upon discharge, the patient can take most of his/her medical reports, which results in incomplete patient information in the hospital. If the patient loses these medical reports for the next visit, he/she has to do the investigations again due to lack of information in the hospital. Moreover, the physician cannot remember the treatment that was previously given to the patient. The HIS in the Hospital A causes difficulties in diagnosis and treatment, and may even cause a certain degree of harm to the patient. In the Hospital A, all care units send information to the statistics department for aggregation and recordkeeping, but again the patient information is incomplete, creating difficulty for the physicians in obtaining information about the patients' medical history.

Aside from the manual system of HIS, other manual systems (such as the pharmacy system, payment system, and medical staff system) are used in managing information related to the Hospital A. When the physician issues a prescription, the information is written on a small piece of paper, which the patient takes to the pharmacy. A pharmacist keeps these small pieces of paper or records the information in the pharmacy system without showing to whom the medicine prescribed. Furthermore, when the patient needs to pay for any healthcare service, the patient has to go to the accounting department. Furthermore, the records of the medical staff are kept in the manual system. Some of the information related to the physicians, such as personal information and schedules, is saved and managed using computer applications such as Microsoft Word and Excel. The schedules of physicians are prepared by the hospital management, and are posted on a bulletin board.

In conclusion, the healthcare system in the Hospital A is based on the manual system. This system is used to manage and control the information about patients, medical staff, and other matters related to the Hospital A. The manual system of the HIS in the Hospital A for the cardiac centre is used to manage and control the patient information, but in an inadequate manner. The reason is the lack of information about patients in the HIS of the hospital. Therefore, healthcare data analysis and information flow is extremely difficult to manage in such a system, and may cause harm to the patient. In addition, the physicians cannot do their work efficiently and accurately via the manual system. Finally, the lack of computerization systems in the hospital environment also results in poor cooperation among the medical staff, especially physicians.

4.2.2 Activities in the Hospital A

The Hospital A provides a wide range of healthcare services daily. This hospital provides comprehensive inpatient and outpatient care services, as well as teaching services for students of the College of Medicine and Nursing. The mission of the Hospital A is to provide quality healthcare services to general patients. In the hospital, some minimally invasive surgical procedures are performed in general surgery, gynecology, and urology. Advanced operations in urology, plastic surgery, and cardiothoracic surgery are also conducted. In the last year, three cases of renal transplantation have been done in the hospital. In the past two years, the hospital was recognized as a centre for training by the Iraqi board of general surgery, urology, gynecology, and internal medicine. The hospital has a considerable number of postgraduate students. During the past five years, the number of patients coming to the Hospital A increased due to the bad security situation in the neighbouring province of Mosul. Therefore, this hospital expects an increase in the number of specialties with all the necessary equipment and well-trained medical staff. The cardiac centre of the Hospital A provides a number of healthcare services, including the diagnosis and treatment of heart diseases in general and of coronary arteries in particular. The Hospital A is the first hospital to conduct cardiac surgical operations in Duhok city. The ultimate goal of the centre is to ensure the provision of up-to-date, high-quality cardiac healthcare services to the populations of Duhok and Kurdistan. This cardiac centre also plans to conduct diagnostic catheterization of children with congenital heart diseases. There are two types of patients: inpatient and outpatient. Work process based on the hospital environment being studied. The patients need to follow the following procedures to obtain treatment, as depicted in Figure 4.1.

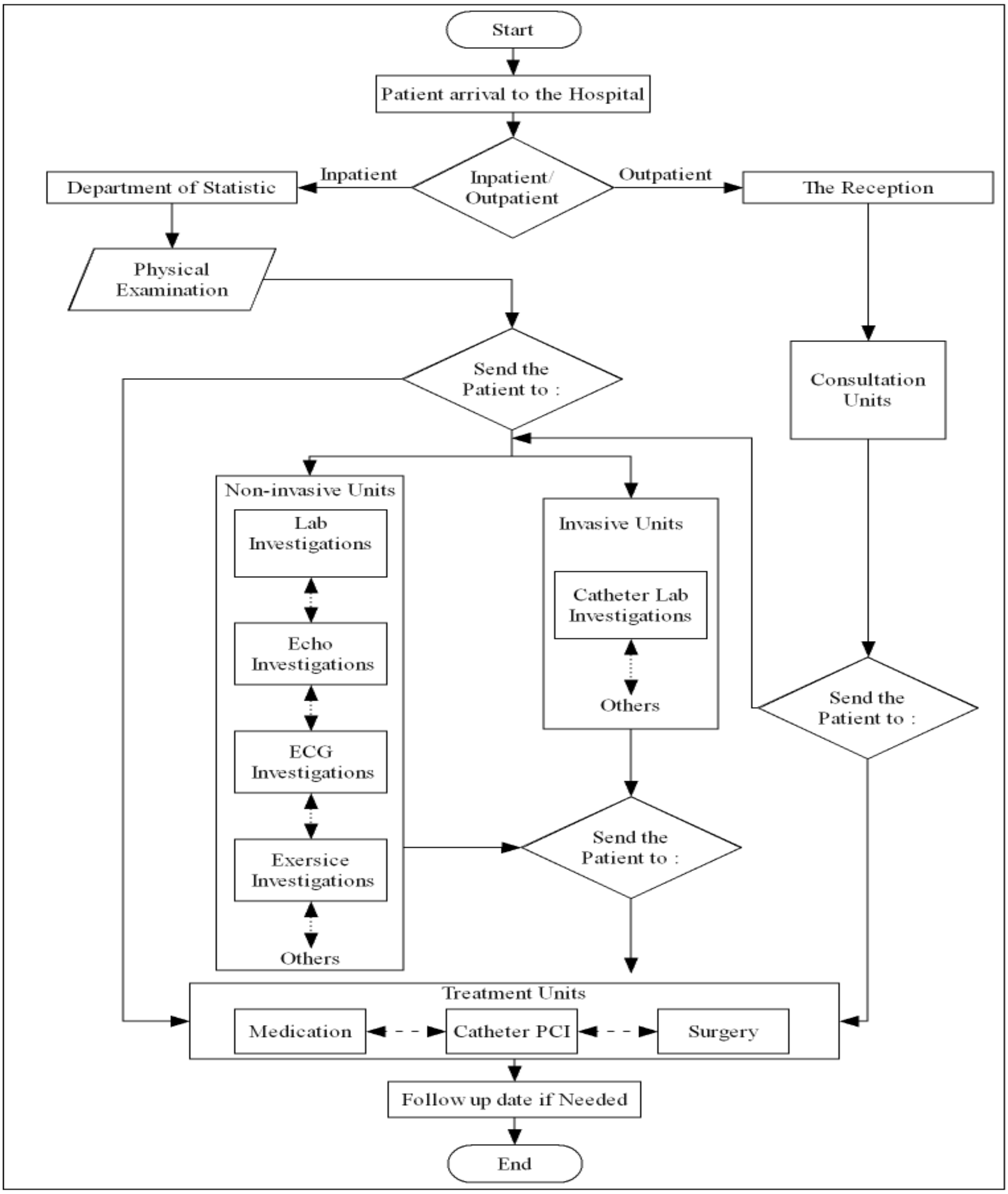


Figure 4.1: Patient Care Flowchart in Hospital A

As Figure 4.1 shows, the inpatient cannot do anything until he/she has a record number and has filed in the statistics department of the hospital. Then, the inpatient gets the treatment in the hospital depending on the physician's decisions and the notes written in the patient's file and kept in the manual system. Meanwhile, the outpatient goes to the reception area of the consultation clinics related to the cardiac centre. The patient buys a ticket to see a physician in such clinics. After the physician sees the inpatient or outpatient, the physician conducts the physical examination. Depending on the results of the physical examination, the physician decides where to send the patient. Thereafter, the patient (with his/her file if an inpatient) goes to the concerned care unit of the cardiac centre (e.g., Consultation, Catheterization, Echo, or Exercise) to get treatment. This is the case if the inpatient has a manual record of the patient information, whereas the outpatient does not have any manual record of the patient information. Additionally, if the inpatient visits the hospital another time, a new record number will be given to him/her as a "new" patient, which means that the inpatient will get different record numbers for different admissions. Therefore, this scenario creates difficulty for the physicians and the hospital management in managing and controlling the information on patients' medical history. Finally, when the physician has obtained all information from investigations of the patient (i.e., information of investigations from Non-invasive units and/or Invasive units), the physician can diagnose the situation of the patient and send the patient to the concerned care units for treatment. Although the provision of healthcare services in this hospital is good, the management of patient information is deficient.

Given the increasing number of patients with congenital heart diseases in Kurdistan, the cardiac centre of Hospital A is pleased to receive the medical team of paediatric cardiac surgeons and staff from foreign cardiac centres to perform surgical operations for children with congenital heart diseases. For example, the medical team of paediatric cardiac surgeons and staff from San Donato Hospital in Milan, Italy, visited this centre in March 2012. During their visit, they performed approximately 30 surgical operations and interventions for carefully selected cases of children with congenital heart diseases in Duhok city.

The Hospital A is also considered as a teaching hospital. The cardiac centre of this hospital provides educational programs for postgraduate students of medicine. In addition, the centre accepts new physicians from government hospitals in Kurdistan and in other parts of Iraq to improve their skills and train them in the new methods of treatment.

4.2.3 Professional Cooperation among Physicians in the Hospital A

In Hospital A, the patient follows several steps of care process, as depicted in Figure 4.1. Patients, especially those with heart problems, go through many care units related to the cardiac centre, such as Emergency, Consultation, Surgery, Catheterization, Echo, ECG, Lab, and/or Exercise. Moreover, the patient treatment process in the Hospital A depends on the physician's decisions. In each unit, at least one physician attends to the visiting patient. The physicians in these care units can cooperate with one another depending on the patient information they have from other physicians in other units as medical reports. All of these medical reports are paper-based and are done manually. Furthermore, the physician has a specific agenda in the cardiac units of the hospital, which means that the physician only works in the cardiac units periodically. Sometimes, the same physician does all the necessary tests for the same patient (except laboratory tests) in addition to diagnosis and treatment. However, this patient care process compels the physician to work individually, which leads to poor professional cooperation among physicians in sharing patient information.

Meetings among physicians in this centre are rarely held to discuss and share the patient information and their experiences. The physicians do not have time to organize their work and share their skills with each other. The reason is that the healthcare organization system in Kurdistan allows specialized physicians to work in both government hospitals and private clinics. Therefore, each physician has his/her own private clinic where he/she goes after work hours in the hospital. Moreover, R&D activities in the hospital environment are weak due to the lack of mechanisms to manage and control the physicians' activities, and to encourage cooperation among physicians in the sharing of healthcare information and skills.

Moreover, the cardiac centre of the Hospital A cooperates with foreign cardiac centres. Every year, different groups of physicians visit the hospital to conduct new surgeries and treatment. The physicians of this centre cooperate with the foreign doctors in conducting new surgeries and treatment, thus enabling the exchange of skills.

The follows are the lessons learned in the Hospital A. Several ways of cooperation among physicians in sharing information and skills are available. First, the physicians in each unit of the centre can provide medical care to patients depending on the patient information and the physician's decisions. Second, the physicians can share their skills through practice treatment sessions. However, the professional cooperation among physicians in sharing information and skills in the patient treatment is extremely poor due to the lack of a computerized HIS in the cardiac centre and in the hospital environment as a whole. As a result, each physician works alone in the patient treatment, and no information system exists to keep track of the physician's activities and enable information sharing.

4.3 Case Study 2 (Hospital B)

This case study is conducted in the Hospital B about the systems used in managing and controlling healthcare information, such as patients' information and treatment, and physicians' information and schedules. This case study also aims to determine the activities used in improving the quality care in the hospital, such as physician activities in patient treatment, and identify the ways of professional cooperation among physicians in the hospital environment.

Hospital B is considered as the leading cardiology hospital in Kurdistan region. It is also regarded as the largest and best-equipped heart surgery hospital in Iraq. This hospital was opened in Erbil city in 2007 by Kurdistan Regional Government Prime Minister Nechirvan Barzani (Kurdistan Regional Government, 2007). The main goal of the Hospital B is to decrease the number of people from Kurdistan and other parts of Iraq who travel abroad for heart-disease treatment.

The Hospital B provides 100 beds for patients. It is a complete cardiac centre that includes several units, such as Emergency, Consultation, Cardiac Surgery, Cardiac Catheterization, Echocardiogram (Echo), Electrocardiogram (ECG), Lab Investigations, and Exercise. It has over 270 staff including physicians, credentialed allied health professionals, cardiac surgeons, nurses, technicians, associate employees, and administrative staff. However, the available number of physicians and surgeons of the cardiac centre in Hospital B are between 20 and 30. This number changes every month or year because programs with changing physicians exist between this hospital and other government hospitals in Kurdistan, and from foreign cardiac centres such as the Netherlands and Germany. This hospital also accepts new physicians from government hospitals in Kurdistan and Iraq to improve their skills and train them on the new treatment. Furthermore, foreign physicians and surgeons visit the Hospital B annually to perform heart surgeries and treat patients who suffer from cardiac diseases. This hospital provides numerous healthcare services, which are detailed in the following subsections.

4.3.1 HIS in the Hospital B

Generally, the healthcare environment in Iraqi hospitals is worse than in most developing countries. The deterioration of the healthcare system in Iraq has been caused by a series of wars and the 2003 invasion. This deterioration has resulted in inadequate healthcare services and healthcare infrastructure in hospitals (Evans, 2004). Therefore, the use of HISs in the region and in the country is unsatisfactory. This assessment is based on the fact that most of the elements related to the strength of using HISs in hospitals function miserably (Ali, et al., 2011). Thus, the majority of the healthcare system in the Hospital B is based on a manual system. The lack of computer-based HIS causes deficient data analysis and information flow (World Health Organization, 2006).

The Hospital B uses the HIS to manage only the patient information, including patient personal information, diagnosis, and treatment. This system has been built in the local database server in the hospital and distributed among the various hospital units. The source of this information based on the technician observations in the hospital. The medical staff, including physicians, nurses, and associate employees work on the HIS to manage the patient information and quickly provide good quality care. The network design topology for the HIS in the Hospital B is shown in Figure 4.2. However, the use of this system is ignored by numerous physicians and nurses because of the time factor and poor management of patient information.

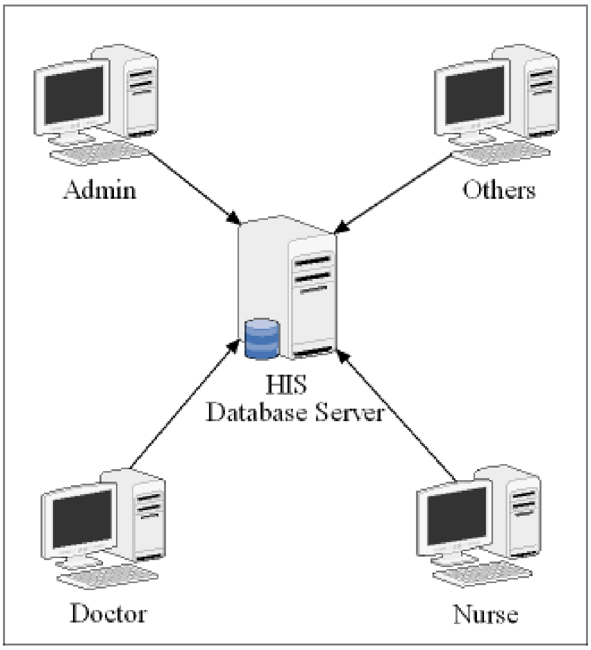


Figure 4.2 : Network Design Topology for HIS in the Hospital B

Currently, the HIS in the Hospital B is used only by the department of statistics to collect patients' medical records. As observed by the researcher, some patient information entered by associate employees in this department is incomplete. Other patient information is recorded in the manual system and saved in the statistics department to manage the patient information, but using the manual system creates difficulty for the hospital in easily managing the healthcare information.

The manual system of healthcare in the Hospital B is organized using a standard form of reports in the hospital units. Sometimes these units keep copies of patient reports of investigation or treatment using computer applications such as Microsoft Word and Excel. The samples of these manual system reports are shown in Appendix F.

Aside from the HIS, other manual systems are used in managing various information related to the Hospital B, such as the pharmacy system, the payment system and the medical staff system. The researcher's observations and interviews with physicians revealed that when the physician prescribes a medicine to the patient, the information is written on a piece of paper that the patient takes to the pharmacy. Occasionally, a pharmacist keeps these pieces of paper or records the information in the pharmacy system without showing to whom the medicine prescribed. Furthermore, when the patient needs to pay for healthcare services, the patient has to go to the accounting department. The payment is also recorded using the manual system. The records of the medical staff are kept using the same system. Some of the information related to the physicians, such as personal information and schedules, is saved and managed using computer-based applications such as Microsoft Word and Excel. The schedules of physicians are prepared by the hospital management and displayed on a bulletin board.

Consequently, almost the entire healthcare system in the Hospital B is based on the manual system. This system is used to manage and control patient information, medical staff information, and other activities related to the Hospital B. The HIS in the Hospital B is used to manage and control the patient information quickly and safely. However, such a system was cancelled by many of the physicians because it resulted in the insufficient management of the patient information. The HIS is no longer used by hospital units, and healthcare data analysis and information flow based on the manual system in any hospital are extremely difficult to manage. The manual system causes harm due to inadequate information needed by physicians in decision making. The lack of computerized systems in the hospital environment also results in poor cooperation among medical staff in such an environment.

4.3.2 Activities in the Hospital B

The activities of the Hospital B are a highly focused facility for cardiology and cardiovascular services. The hospital provides comprehensive inpatient and outpatient heart care from the onset of heart problems through rehabilitation, and offers community outreach and education programs to promote preventative care and healthy living. The mission of the Hospital B is to provide the healthcare needs of the community and to serve all people with dignity. The hospital also contributes to the reduction of morbidity and mortality from congenital heart diseases and enhances the skills of local health professionals.

In the Hospital B, the annual average utilization has reached 2,500 patient visits, 250 surgeries, and 800 catheterizations. The design, management, staffing, and operation of the hospital are all focused on the patient’s perspective, needs, and overall comfort.

In the work process of the Hospital B, the patient has to wait until a record and an appointment have been prepared. First, the patient goes to the statistics department to check whether he/she is a new or old patient. If the patient is new, a new record is opened and the information about the patient is registered. If the patient is old, the information on visiting the patient is registered. Then, the patient with his/her file is sent to the concerned care unit in the hospital (e.g., Consultation, Catheterization, Echo, or Exercise) to get care. Work process based on the hospital environment being studied. The patients need to follow the following procedures to obtain treatment (see Figure 4.3).

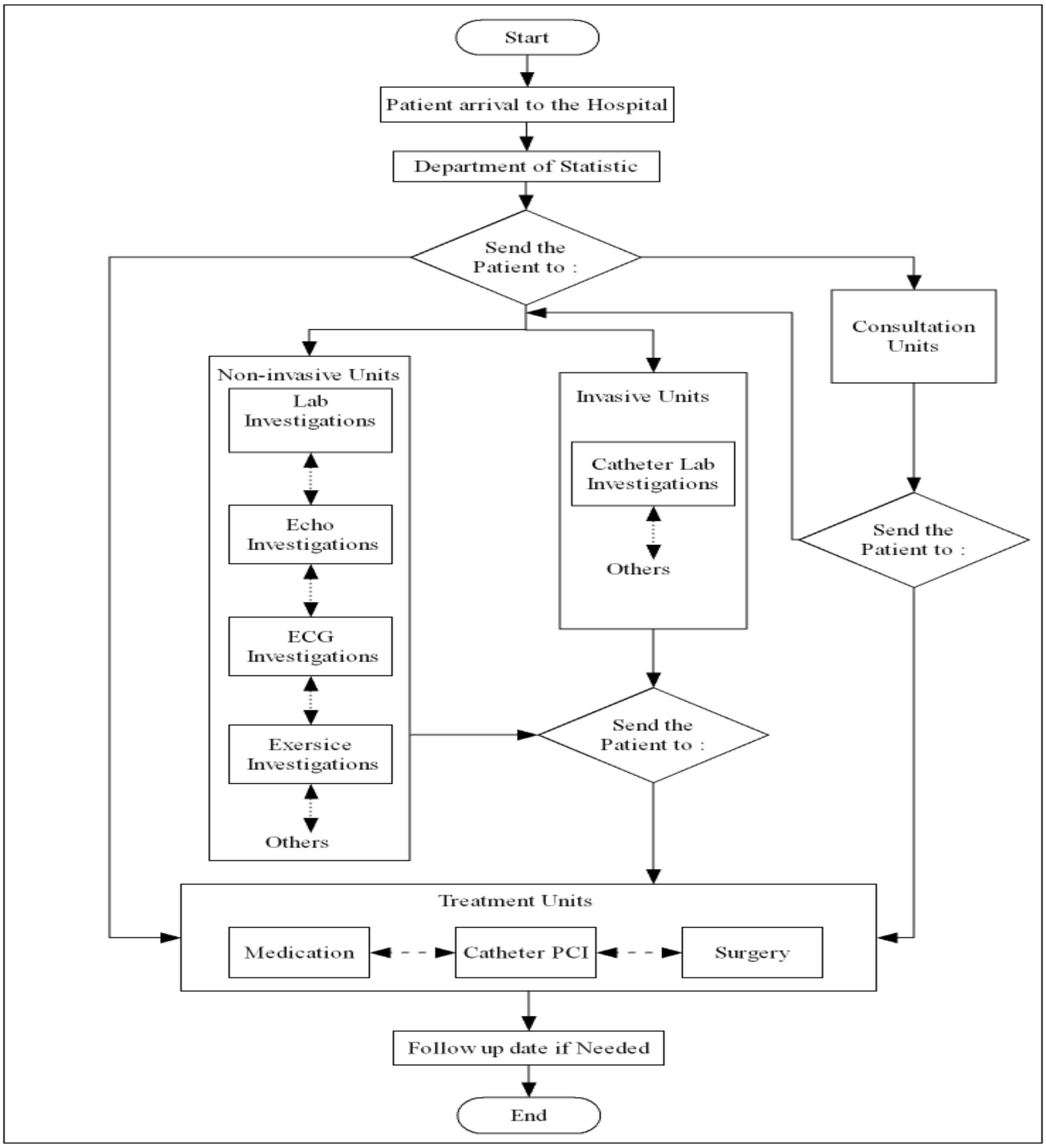


Figure 4.3 : Patient Care Flowchart in the Hospital B

As Figure 4.3 shows, when the patient is sent to the consultation, non-invasive, invasive, or treatment units, the physician of the patient decides on the next steps for the patient care. For example, if the patient is in the consultation unit, the physician makes a decision to send the patient either to non-invasive units and/or invasive units for further investigation, or to treatment units for treatment. If the patient is in the non-invasive unit, the physician sees the results and decides whether the patient will be sent to the invasive or to treatment units. Then, in the treatment units, the patient will get the proper treatment depending on the physician's diagnosis and decision.

Given that the Hospital B is a hospital that specializes in heart and blood vessel care, it provides a number of benefits to patients, including the following:

1. A special design to facilitate the delivery of healthcare to the patients;
2. Private rooms that are designed and equipped for every stage of heart care and treatment;
3. Point-of-care service provided in a cost-effective manner that meets patient needs rather than the hospital's convenience;
4. Coordinated and managed patient services to ensure high-quality care and continuous monitoring, control, and improvement of resource utilization; and
5. Cross-trained, multi-disciplinary staff members who assist physicians in patient care. The nursing staff is trained to perform several different tasks simultaneously. Involving family members in the decision related to their loved ones is an essential component of care delivery. The ability to understand cardiac and vascular disease gives family members the opportunity to assist in the recovery process of their loved ones.

The Hospital B is also considered as a teaching hospital, which has many components, including health education of families who have patients with congenital heart diseases, and education programs of postgraduate students in medicine.

4.3.3 Professional Cooperation among Physicians in the Hospital B

In the Hospital B hospital, the patient follows a number of steps to get good quality care, as depicted in Figure 4.3. The patient goes through various units in the hospital, such as Emergency, Consultation, Surgery, Catheterization, Echo, ECG, Lab, and/or Exercise. The process of patient treatment in the Hospital B depends on the physician's decisions. In each unit, at least one physician cares for the visiting patient. The physicians in the hospital units can cooperate by providing care for the same patient depending on the patient information they have from other physicians of other units as medical reports. Mostly, these medical reports are done manually in a paper-based system. However, the process of patient care requires the physician to work individually, which means that cooperation among physicians in sharing patient information remains weak in the hospital environment.

As shown by interviews with professional physicians in the Hospital B, a weekly meeting is held among physicians in the R&D unit of the hospital. The goal of the R&D unit activities is to manage the verbal communication among physicians to discuss the difficult cases of patients and the avenues for treatment. These activities also update the physicians' knowledge and provide better treatment for patients through information sharing. Additionally, the R&D unit organizes a joint conference between surgeons and physicians, but these activities are still weak to have a good cooperative system for sharing patient information among physicians in the hospital environment.

Moreover, the Hospital B cooperates with foreign cardiac centres. Every year, different groups of physicians visit the hospital to conduct new surgeries and treatment. The Hospital B physicians work with the physicians from foreign centres to conduct these new surgeries and treatment and share their experiences in patient treatment.

Lessons learned in the Hospital B, there are ways of cooperation among physicians in sharing information and skills in the patient treatment. First, the physicians in each unit of the hospital can provide medical care to patients depending on the information and the physician decisions. Second, the physicians can share their skills in treatment through weekly discussions organized by the R&D unit. Third, the physicians can share their skills through practice sessions during the treatment. However, the professional cooperation among physicians in sharing information and skills in this area is still weak in the same and in different hospitals due to the lack of computerized HIS in the hospital (see the previous subsections). Thus, each physician works independently in the patient treatment, and no system exists to keep a record of the activities in the treatment for sharing information among physicians.

4.4 Summary

Two healthcare centres, Hospital A and Hospital B, were included in this study as case studies. Including these two case studies is significant to address the research question (as a real situation), develop a FHIS system, and find useful solutions to the research problem. Conducting these two case studies involves the management and control of the HIS used in the hospital environment. Furthermore, these case studies are concerned with determining the activities used in enhancing cooperation among physicians and healthcare services in the hospital environment.

The first case study in this research project was conducted with the Hospital A. This hospital provides extensive general patient care, including heart care. However, the healthcare system in the Hospital A is based on the manual system. Therefore, the management and control of healthcare information is deficient. In addition, this manual system of healthcare information leads to poor cooperation among physicians and forces each physician to work alone. Although some programs in the Hospital A aim to encourage good cooperation among physicians in sharing their experiences, this kind of cooperation remains poor in the hospital environment.

The Second case study in this research project was conducted at the Hospital B. This hospital provides extensive heart care. However, almost the entire healthcare system in the Hospital B is based on the manual system. Therefore, the management and control of healthcare information is deficient. The manual system of handling healthcare information results in poor cooperation among physicians. Although some programs and units in the Hospital B support cooperation among physicians in sharing their skills in the patient treatment, such cooperation remains weak in the hospital environment.

In conclusion, this research project is concerned with two real case studies of hospitals (i.e., the Hospital A and the Hospital B), in addition to the survey instruments used. Computer-based healthcare systems are lacking in these two hospitals. Thus, physicians are forced to work individually in the hospital environment. There is evidence of poor cooperation among physicians in sharing information and skills about patient treatment within same and between different hospitals.

The next chapter will detail data analysis and findings of empirical data that collected from the data collection instruments used in first stage of this study.

CHAPTER 5

DATA ANALYSIS AND FINDINGS

5.1 Introduction

This chapter begins with a description of data collection instruments used to collect empirical data of this study and of responses rate on these instruments. In this study, two hospitals (Hospital A and Hospital B) in the Kurdistan region of Iraq were conducted as the subjects of case studies to address the research objectives. This chapter follows analysis of empirical data through the combination process of data that collected from the data collection instruments. This combination process of data is used the QUANT→qual sequence model (see Figure 3.2 in chapter 3) in a complementary fashion to guide the researcher in the data analysis and discussion of findings. Based on that, this chapter shows data analysis and findings of this study based on the objectives to answer the research questions. Then, the discussion of findings is followed to address the research problem and find convenient solutions.

5.2 Data Collection and Responses Rate

In this study, the participants included hospital managers, doctors, senior house officers, intervention cardiologists, and cardiac surgeons from the Hospital A and the Hospital B, as previously mentioned in this chapter. The survey questionnaire and semi-structured interview techniques were used to collect data.

A total of 100 questionnaires were personally handed to the respondents. The response rate was 81%, and only the fully completed questionnaires were included for analysis. The demographic section of the questionnaire showed the hospital name, and the gender and highest academic qualification of the respondents (see Table 5.1).

Table 5.1 : Demographic Information about the Survey Respondents (N=81)

Respondents	**Frequency**	**Percentage**
Hospital		
(n=81)		
Hospital A	65	80.0
Hospital B	16	20.0
Total	81	100.0
Gender		
(n = 81)		
Female	13	16.0
Male	68	84.0
Total	81	100.0
Qualifications		
(n = 104)		
Diploma	6	07.40
Bachelor	39	48.10
Master	5	18.50
PhD	21	25.90
Total	81	100.0

In Table 5.1, 65 participants (80%) were from the Hospital A and 16 (20%) were from the Hospital B. Of the total, 68 (84%) were male and 13 (16%) were female. The academic qualifications of the respondents are as follows: 6 (7.40%) had a Diploma, 39 (48.10%) had a Bachelor's degree, 5 (18.50%) had a Master's degree, and 21 (25.90%) had a PhD in medicine. The overall responses in this category showed that the majority of the physicians had a basic bachelor's degree instead of a Master's or PhD degree, implying a low number of professional physicians in the healthcare centres of Kurdistan region, especially cardiac centres, being studied.

In-depth interviews were conducted with 10 specialist physicians, including cardiac centre managers, intervention cardiologists, and cardiac surgeons from a subsample of the population for this study. In the Hospital A, six specialist physicians, including the manager of the cardiac centre, were interviewed; meanwhile, in the Hospital B, four specialist physicians, including the manager, were interviewed. The in-depth interviews were crucial in the investigation of issues in a more in-depth manner that could not be studied in the research instrument of questionnaire.

The responses obtained through questionnaires and interviews were combined and presented to determine the current levels of cooperation among physicians in sharing information and skills in patient treatment within selected hospitals, determine the factors affecting such cooperation, and determine how R&D unit activities influence cooperation among hospital physicians. Furthermore, this study was intended to develop a proposed FHIS model based on the fractal theory and the participants' requirements to improve cooperation among physicians within the hospital environment in Kurdistan region of Iraq.

5.3 Current Levels of Cooperation among Physicians in the Hospital Environment in the Kurdistan Region of Iraq

Section C in the questionnaire was intended to determine the current levels of professional cooperation among physicians in sharing information and skills in patient treatment in the hospital environment. This section contained nine types of cooperation with responses provided on a five-point Likert scale. Respondents were asked to rate their opinion on the cooperation among them on a scale of 1 to 5 (1 = no cooperation, 2 = little cooperation, 3 = some cooperation, 4 = good cooperation, and 5 = very good cooperation), and nine types of cooperation among physicians were analyzed, with a mean rating of 1.994 indicating minimal cooperation (see Table 5.2). For this study, a minimal cooperation identifies a weak cooperation.

In Table 5.2, mixed responses were obtained from types 1 and 2 of cooperation, in which 56.8% and 86.4% indicated "no cooperation" and "little cooperation," respectively, and 43.2% and 13.5% indicated "some cooperation" and "good cooperation," respectively. These results indicated that there was poor cooperation in the sharing of information and physicians' skills in the same and in different workplaces.

Table 5.2 : Descriptive Results of the Level of Professional Cooperation among Physicians (N=81)

Type of Cooperation	**Responses**	**%**	**Mean & Std. D.**
1) Physicians sharing of skills in the same hospital	No Cooperation Little Cooperation Some Cooperation Good Cooperation	16 (19.8) 30 (37.0) 25 (30.9) 10 (12.3)	**Mean**= 2.36 **Std. D.** = .940
2) Physicians sharing of skills in various hospitals in your town	No Cooperation Little Cooperation Some Cooperation Good Cooperation	34 (42.0) 36 (44.4) 7 (8.6) 4 (4.9)	**Mean**= 1.77 **Std. D.** = .810
3) Physicians sharing of skills by means of a database for distributing information among them in your hospital	No Cooperation Little Cooperation Some Cooperation Good Cooperation V. Good Cooperation	37 (45.7) 33 (40.7) 4 (4.9) 5 (6.2) 2 (2.5)	**Mean**= 1.79 **Std. D.** = .971
4) Physicians sharing of skills through research and development activities among hospitals	No Cooperation Little Cooperation Some Cooperation Good Cooperation V. Good Cooperation	39 (48.1) 24 (29.6) 9 (11.1) 5 (6.2) 4 (4.9)	**Mean**= 1.90 **Std. D.** =1.136
5)Physicians sharing of skills from different hospitals in order to improve their skills	No Cooperation Little Cooperation Some Cooperation Good Cooperation V. Good Cooperation	25 (30.9) 41 (50.6) 5 (6.2) 4 (4.9) 6 (7.4)	**Mean**= 2.07 **Std. D.** = 1.116
6) Physicians sharing of skills with regard to connecting healthcare information systems among hospitals in order to enhance the quality of healthcare services	No Cooperation Little Cooperation Some Cooperation Good Cooperation V. Good Cooperation	23 (28.4) 44 (54.3) 3 (3.7) 4 (4.9) 7 (8.6)	**Mean**= 2.11 **Std. D.** = 1.140
7) Cooperation among physicians with regard to design system for healthcare activities among hospitals	No Cooperation Little Cooperation Some Cooperation Good Cooperation V. Good Cooperation	38 (46.9) 31 (38.3) 3 (3.7) 3 (3.7) 6 (7.4)	**Mean**= 1.86 **Std. D.** = 1.148
8) Physicians sharing of skills among different hospitals in order to increase the use of human resources	No Cooperation Little Cooperation Some Cooperation Good Cooperation V. Good Cooperation	27 (33.3) 36 (44.4) 10 (12.3) 4 (4.9) 4 (4.9)	**Mean**= 2.04 **Std. D.** = 1.054
9) Cooperation among physicians with regard to distributing a new activity happens in the system among them in real-time	No Cooperation Little Cooperation Some Cooperation Good Cooperation V. Good Cooperation	27 (33.3) 35 (43.2) 11 (13.6) 4 (4.9) 4 (4.9)	**Mean**= 2.05 **Std. D.** = 1.059

However, these results also indicated that there was some cooperation and good cooperation (see Table 5.2). This diversity of responses was mainly due to the work process in the hospitals, almost all of which used the manual system. The doctors meet regularly to discuss patient-related matters, but such a meeting was valid only in the case of one selected hospital. For example, one of the expert physicians in the interviews said, “We have a consultation meeting weekly; we discuss the difficult cases of our patients” (BPY2) (see Table 3.4 and Appendix B for reference). Another one said, “We have a meeting every week, and we discuss the difficult cases and other activities” (BPY1). Additionally, the computerized HIS was valid only in one selected hospital; as one of the physicians said, “In our centre, we have an intranet database system, but it is local, centralized and only for our patient records” (BPY1).

Although some cooperation in sharing patient information was observed, the majority of the respondents declared that they had none or little cooperation in other areas, as depicted in Table 5.2. In the type 3 of cooperation, 86.4% of the physicians reported no cooperation and little cooperation in sharing their skills via a database for distributing information in the hospital. This previous rating of the respondents indicated that the hospital almost completely used the manual system in daily work. One proof is that a specialist physician of the Hospital A said, “In our work, we have paper forms to record our patients’ information” (APY3). However, in the same type of cooperation, 4.9%, 6.2%, and 2.5% of the respondents reported some cooperation, good cooperation, and very good cooperation, respectively. This low rate of diversity was observed in the Hospital B, which has a simple computerized HIS. As one of the physicians in the interviews said, “There is a database in our hospital and there is an intranet to connect departments of the hospital together to see the patient record in each department” (BPY3). In the Hospital A, one of the interviewees said, “We only have partial information about our patients in the catheterization unit recorded on the computer” (APY3). Thus, in the type 4 of cooperation, participants were asked to give their opinion on the physician sharing of skills through R&D activities among hospitals. Of the total number of participants, 77.7% reported that there was no cooperation and little cooperation among physicians, whereas the rest of the participants reported some and good cooperation. This diversity of responses was principally due to the availability of an R&D unit in only one hospital, which is evidenced by the statements of some interviewees:

> "For these activities, we are starting now. We have a consultation meeting weekly...." (BPY2).

> "We have in this unit a consultation meeting weekly to discuss some difficult cases of our patients and how we can treat these cases" (BPY3).

> "Until now, I have no idea about this unit and its activities" (BPY4).

> "For this issue, the activities of the R&D are weak, and at most we provide the information we have about our patients to the researchers when necessary..... In addition, the role of R&D activities in our centre is poor, because there are no facilities for creating the R&D unit" (APY2).

> "The activities of R&D are poor in our centre for reasons such as the absence of a database system with limitation of experiences, and really there is no unit to do any of these activities" (APY5).

For the other types of cooperation, the participants highly rated that there was no cooperation and little cooperation among physicians in sharing patient information and physician skills in patient treatment in the same and in different hospitals.

Despite the presence of a few specialist physicians, majority of the interviewees said that there was weak cooperation among physicians. For example, one of the participants said, "There is poor cooperation among doctors because each doctor works independently, and there is no system to capture and save the information of all activities in our hospital" (APY1). Another one said, "In our centre, we have good cooperation among physicians but weak cooperation with other physicians outside this centre" (BPY2). This weak cooperation was largely a result of not having distributed information systems and inadequate IT infrastructure support.

In summary, the results indicated the following:

a) The sharing of skills or activities among physicians in the two government hospitals in Kurdistan is inconclusive because the high ratings are weak. The reason is mainly the lack of computerized healthcare systems. Therefore, there is a lack of cooperation among physicians in sharing information and their skills in patient treatment within the same hospital and among different ones.

b) The level of cooperation among physicians with regard to the design system for connecting R&D activities among hospitals to improve physician skills and enhance healthcare services indicated extremely low ratings. The implication is that the efficiency of both the whole information system of their hospital and those of other hospitals cannot be perceived, and the real-time distribution of a new activity in the system among physicians cannot be occurred.

5.4 Factors Affecting Cooperation among Physicians within the Hospital Environment in the Kurdistan Region of Iraq

This study investigated the factors affecting cooperation among physicians with regard to the sharing of information and skills in patient treatment in the Iraqi hospital environment. Section B of the questionnaire was on the background information related to the HIS in hospitals. Some items in this section indicated certain factors that influence cooperation among physicians in sharing information from the respondents' opinion (see Table 5.3).

Table 5.3 : Descriptive Results of Questions in the Background Information Section of Questionnaire (N=81)

Question	Response	%
1) Do you know how to use the computer-based systems?	Yes No	81 (100.0) 00 (000.0)
2) Do you know how to use and surf in the internet?	Yes No	81 (100.0) 00 (000.0)
3) Did you take any information about healthcare services from the internet?	Yes No	73 (90.10) 08 (09.90)
4) Are there any healthcare information systems in your hospital about healthcare services?	Yes No	21 (25.90) 60 (74.10)
5) Are there any healthcare information systems between different hospitals in your town?	Yes No	09 (11.10) 72 (88.90)
6) Does the hospital in your town have a system for reducing medical errors?	Yes No	08 (09.90) 73 (90.10)
7) Is there a system that shows the level of confidence in the results of operations in your hospital?	Yes No	10 (12.30) 71 (87.70)
8) Do you think the hospitals in your town are trusted units?	Yes No	43 (53.10) 38 (46.90)
9) Is there research and development unit in every hospital in your location?	Yes No	02 (02.50) 79 (97.50)

Table 5.3 shows that all physicians knew how to use computer-based systems and that they browsed through the Internet to improve their knowledge to provide good healthcare. Of the total number of respondents, 73 (90.10%) said they used Internet healthcare information, but the information obtained was inaccurate in some cases (American Pain Foundation organization, 2010; BBC, 2010; Team, 2010). Using the computer-based systems was not a problem to these physicians, but the main concern was the lack of reliable healthcare information in their HIS environment, as indicated by the following data: 60 respondents (74.10%) said that they did not have computer-based HISs, and 72 (88.90%) said that there was no distributed HIS between their hospital units and other hospitals. Almost the entire healthcare system in the hospital was based on the manual system. As one of the interviewees said, “In our hospital, I think there is one database system in the statistics division; however, it is inadequate, deficient, and almost not electronic” (APY4). Another one said, “We only have some information about our patients saved on the computer, but it is not complete, again because of the

absence of a database system...” (APY5). Moreover, 73 respondents (90.10%) said that there was no available procedure to reduce medical errors, 71 respondents (87.70%) indicated that there was no mechanism to determine the confidence level of surgeons and physicians, and 79 respondents (97.50%) stated that there was no unit in the hospital that helped improve patients’ process activities and made the hospital a reliable R&D unit.

In the suggestions section of the questionnaire, the physicians were asked to identify the factors that influence the cooperation among them in terms of skills sharing. Most of the respondents answered that each physician worked independently, and that there was no electronic HIS through which their activities were saved, monitored, and distributed. For example, one of the specialist physicians said, “We lack the equipment necessary in patient treatment, and we need much more experience, particularly by connecting with medical professionals outside this hospital to obtain more knowledge about patient treatment” (BPY2). The majority of the respondents also said that most physicians did not have time to organize their work and share their skills with others. The reason is that the healthcare organization system in Kurdistan allows specialized doctors to work in government hospitals and private clinics simultaneously (Heshmati & Darwesh, 2007). Therefore, each physician has his/her own private clinic where he/she goes after working in a hospital. In addition, most of them reported weak R&D activities in their hospitals. Some problems in sharing information and physician skills in the patient treatment among physicians have been identified; for instance, one of the specialist physicians said, “We have an intranet database system, but it is local, centralized, and only for our patient records” (BPY1). Another said, “I have no idea about the database. Maybe, there is one, but I haven’t used it until now” (BPY4). Another said, “...most of our work is paper-based, not computerized” (APY6).

Furthermore, majority of the physicians in the interview mentioned a lack of cooperation among them due to the absence of an electronic HIS, that most of the work was paper-based, that the R&D activities were weak, and that there was no time for doctors to see the patients' medical history and share their experience with others. For instance, one of the interviewees said, "We don't have complete patient records and medical history because our system is mainly based on papers, and the management has no interest in improving services such as developing a good information system." The same interviewee said, "The R&D activities are weak...we have not progressed to reach the level of the advanced centres in the world. We are interested in working on this unit as soon as possible" (APY1). Another interviewee said, "... the time factor also affects our work because this centre is very busy. It has many patients and a limited number of doctors" (APY6).

In summary, the results indicated that certain factors that were supposed to facilitate cooperation among physicians in sharing information and skills are weak, as demonstrated by the following:

(a) A manual system of healthcare management is used, thus making paper-based information difficult to manage, control, and share.

(b) Physicians work individually in patient treatment due to the time factor and the absence of an electronic HIS in their healthcare system environment.

(c) The acquisition of new knowledge in real time via the manual system of healthcare in the same hospital and in different ones is difficult for physicians.

(d) There are weak R&D activities in the Iraqi hospital environment.

5.4.1 R&D unit activities

This study determined how the R&D unit activities affect cooperation among hospital physicians. Section D of the questionnaire was about the work of the R&D unit in the hospital environment. This section contained nine statements on the role of R&D activities in the hospital, with responses provided on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3= neutral, 4 = agree, and 5 = strongly agree). Respondents were asked to provide feedback on the role of R&D unit activities in the hospital. The summary of the responses is presented in Table 5.4.

Table 5.4 : Descriptive Results of the Work of R&D Unit Activities (N=81)

Statement	**Responses**	**%**	**M. & Std. D.**
1) The research and development unit improves the cooperation among physicians' skills.	Neutral Agree Strongly Agree	6 (7.4) 33 (40.7) 42 (51.9)	**Mean** = 4.44 **Std. D.** = .632
2) The research and development services in your hospital have benefits to increase the quality of healthcare services.	Strongly Disagree Disagree Neutral Agree Strongly Agree	1 (1.2) 2 (2.5) 3 (3.7) 43 (53.1) 32 (39.5)	**Mean** = 4.27 **Std. D.** =.758
3) The research and development unit makes the hospitals in your town more trusted units.	Neutral Agree Strongly Agree	2 (2.5) 35 (43.2) 44 (54.3)	**Mean** = 4.52 **Std. D.** =.550
4) The hospitals contain decentralized and autonomous organizational units for healthcare services supporting, as a research and development units.	Strongly Disagree Disagree Neutral Agree Strongly Agree	1 (1.2) 1 (1.2) 15 (18.5) 46 (56.8) 18 (22.2)	**Mean** = 3.98 **Std. D.** = .758
5) The connection between similar autonomous units (i.e. research and development units), from different hospitals increases the quality of healthcare services.	Strongly Disagree Neutral Agree Strongly Agree	1 (1.2) 5 (6.2) 44 (54.3) 31 (38.3)	**Mean** = 4.28 **Std. D.** = .693
6) The integrated view of the research and development services system among hospitals is an efficient information system for researchers and physicians.	Strongly Disagree Neutral Agree Strongly Agree	1 (1.2) 8 (9.9) 47 (58.0) 25 (30.9)	**Mean** = 4.17 **Std. D.** = .703
7) For weak research and development activities in your hospital, many physicians refer to web resources to help them in completing their research and patient treatments.	Neutral Agree Strongly Agree	12 (14.8) 49 (60.5) 20 (24.7)	**Mean** = 4.10 **Std. D.** = .625
8) The research and development activities in the hospitals in your town depend on the paper-based system managed and controlled by the group of researchers (physicians).	Strongly Disagree Disagree Neutral Agree Strongly Agree	4 (4.9) 6 (7.4) 24 (29.6) 30 (37.0) 17 (21.0)	**Mean** = 3.62 **Std. D.** = 1.056
9) The research and development activity in the hospital should circulate healthcare information simply and quickly among specialists to enhance the quality of healthcare services.	Strongly Disagree Disagree Neutral Agree Strongly Agree	1 (1.2) 1 (1.2) 1 (1.2) 31 (38.3) 47 (58.0)	**Mean** = 4.51 **Std. D.** = .709

In Table 5.4, the mean rating of respondents, 4.210, indicated that the role of the R&D unit activities was crucial in improving the cooperation among physicians to enhance healthcare services. Hence, 92.6% of the respondents (see Table 5.4) agreed and strongly agreed that the significant role of the R&D unit in the hospital is to improve the cooperation among physicians in sharing their skills. Of the total number, 92.6% also agreed and strongly agreed that this unit can enhance the healthcare services in the hospital environment. In addition, 97.5% of the respondents agreed and strongly agreed that the improvement of physician skills and the enhancement of healthcare services can result in more reliable services. Among the respondents, 79.0% and 92.6% agreed and strongly agreed that the hospitals contained decentralized and autonomous organizational units, and that the connection between these similar autonomous units could produce better healthcare services in terms of quality, respectively. Thus, 85.2% of the respondents indicated that there was no system for R&D activities in their hospital environment or a system that connects HISs. Consequently, the physicians conducted their research on the Web resources for additional information of patients' treatment. However, 58.0% of the respondents agreed and strongly agreed that most hospitals' activities use a paper-based system, which creates difficulty for the physicians in searching for particular information in a large volume of information stored on paper. Additionally, 96.3% of the respondents indicated that the best way to enhance healthcare services in hospitals is to have a mechanism that can rapidly distribute information among specialists.

A simple regression analysis was conducted to identify the best predictors of the dependent variable and show the proportion of variance in the dependent variable (cooperation among physicians) explained by R&D unit activities. The dependent variables were shown in Table 5.2. The independent variables were shown in Table 5.4. Overall the mean of each respondent of the dependent variables and the independent variables was considered in the simple regression analysis. A direct method entry was used in the simple linear regression analyses. The standard regression with a direct method entry was used to measure the relationships among variables. The summary of the simple regression results is presented in Tables 5.5 to 5.7. The results indicated that 75.2% of the variance in cooperation among physicians with regard to the sharing of information and skills in patient treatment was explained by R&D unit activities. The test statistic was significant at the 0.01 level (F (1, 79) = 7.230; p = 0.008).

Table 5.5 : Standard Regression Model Summary

Model	**R**	**R2**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.867	0.752	0.715	17.948

Table 5.6 : ANOVA, Regression Significance

Model	**Sum of squares**	**Df**	**Mean square**	**F**	**Sig.**
Regression	285.669	1	285.659	7.230	.008a
Residual	4662.133	79	39.510		
Total	4947.792	80			

Table 5.7 : Regression Coefficients of Standard Regression Model (Dependent variables: Cooperation; N = 81; p < 0.01)

Model	**Unstandardized coefficients**		**Standardized coefficients**	**T**	**Sig.**
	B	**Std. Error**	**Beta**		
Constant	1.972	0.574		3.122	0.008
R&D	1.549	0.576	0.240	2.689	0.008

The standardized regression coefficients (Beta) give an indication of the contribution of independent variables in predicting the dependent variable (Aron, Aron, & Coups, 2005) (see Table 5.7). The Sig (p) for independent variables represents a measure of the significance of this variable in predicting the dependent variable. For the R&D unit activities variable, the test was statistically significant (t = 2.689, Beta = 0.240; p = 0.008), which shows a significant impact of R&D unit activities on the cooperation among physicians.

The majority of the doctors interviewed emphasized that the role of the R&D unit was to facilitate verbal communication among physicians regarding patient information and treatment skills, updating the knowledge of physicians, and providing the best treatment for patients. For instance, one of the physicians said, “The benefits of R&D unit activities include updating our knowledge and providing better treatment for patients by enabling us to see the results of any patient, which will give the patient a good management depending upon the results” (BPY2). Another said, “We have in this unit a consultation meeting weekly to discuss some difficult cases of our patients... The main objective of this unit is to provide and gather data for visiting patients with information of diagnosis, treatment, and surgery to make the work of doctors easier and faster” (BPY3). Another interviewee said, “For this issue, the R&D activities are weak, and we only provide the available information about our patients to the researchers.... In my opinion, it improves healthcare services in the hospital.... It improves the knowledge of researchers and physicians, and makes the hospital a trusted unit, which in turn leads to the improvement of healthcare services” (APY1).

The data collected from interviewees revealed that the key role of the R&D unit activities in the hospital environment was improving cooperation among physicians in sharing patient information and treatment skills. This was possible in one of the hospitals organizing weekly verbal communication among local physicians and by enabling physicians to participate in practice sessions during the patient treatment. However, these R&D activities in the hospital environment were still deficient to improve cooperation among physicians in sharing information and skills, given the lack of a computerized system to manage, control, and share these activities.

In summary, the results indicated the following:

a) The role of R&D unit activities in improving cooperation among physicians and enhancing healthcare services in two government hospitals in Kurdistan was conclusive because the agreement ratings were strong. The implication is that the critical role of the activities in this unit is to improve skills sharing among physicians.
b) Designing a healthcare information system to connect R&D units among hospitals and to control hospital activities, especially physician activities, to improve physicians' skills and enhance healthcare services indicated high agreement ratings. Thus, it can be said that the efficiency of seeing both the whole information system of their hospital and those of other hospitals, and the real-time distribution of a new activity takes place in the system to improve cooperation among physicians.

5.5 Cooperative HIS Environment as the Fractal-based System

The cooperation among physicians is a critical issue in the cooperative HIS environment to maximize information sharing and provide accurate information in an appropriate and timely manner to support physicians' decisions, thus resulting in better healthcare services. In this research, the improvement of cooperation among physicians in sharing information and skills in the hospital environment can be accomplished with a fractal-based architecture for integrated cooperative HISs. The decision to select the fractal-based information system was mainly based on the fact that the behaviour of such a system is more open, autonomic, flexible, and cooperative than conventional systems. The fractal-based information system can only perform fractal functions if it possesses fractal features.

The fractal features are self-similarity, self-organization, dynamics and vitality, navigation, and goal-orientation. The self-similarity feature refers to all units in the fractal system with the same structure or goals. The self-organization feature pertains to the freedom of fractals in the organization and implementation functions. The dynamics and vitality feature denotes the information that can be updated among system units whenever needed. The navigation feature induces cooperation among fractals. The goal-orientation feature enables the system goals to emerge from the objectives of individual fractals.

Given that the healthcare organization system contains individual centres supported by autonomous HISs, such as hospitals, the cooperative HIS environment can be adapted as the fractal system by connecting the similar units of healthcare centres. The development of cooperative HISs based on the FHIS system proposed in this research can perform fractal functions by possessing fractal features.

Therefore, as depicted in Table 5.4, 79% of the respondents mentioned that the hospitals contain decentralized and autonomous organizational units for healthcare services supporting. Additionally, 93% of them reported that the connection between similar autonomous units within the hospital environment increases the quality of healthcare services. All the physicians also stated that the healthcare organization has decentralized and autonomous units. The goal of these units was the same, especially in patient treatment. For example, one of the physicians said, "In our hospital, each unit works independently, but they have the same goals, especially in terms of providing good care to patients" (APY4). Another interviewee said, "Each unit in our centre works independently, and these units work together to come up with a good decision on the patient's case to provide the best quality of care" (BPY1). In addition, the structure of process activities of hospital units was a bottom-up process in which the data of patient(s) from different departments are collected, after which the decision makers (physicians) make the diagnosis. Focusing on the patient treatment, the hospital and physicians can arrive at decisions autonomously. For instance, one of the interviewees answered the question: What degree of autonomy do you have in decision making in this hospital? The answer was, “We have full autonomy from other units in our operation to make a decision on the patient’s case” (APY2). Another said, “We have autonomy in decision making on patient treatment from other units or from other hospitals. Sometimes we have a committee that discusses a decision on the patient’s case to provide a good treatment” (BPY2). Therefore, the workflow of the physician’s activities in the patient treatment can be based on the physician’s experience and can be represented as a flowchart depending on the answers of the specialist physicians interviewed, as shown in Figure 5.1. The specialist physicians had the same answer to the question related to the patient treatment process in the hospital. The question was: Can you describe the patient treatment process in your hospital? Some of the answers are as follows:

> “The process of patient treatment starts from consultation units, followed by medical treatment or non-invasive units (i.e., ECG, Echo, Exercise Test, Lab Investigations, and so on) for more investigations. Thereafter, we send our patient to medical treatment, but the information is insufficient to make a decision in most cases. For the previous reason, we send our patient to an invasive unit (i.e., Catheterization unit) to obtain more information to come up with the correct decision (i.e., 100%) to diagnose our patient’s case and provide him/her a good treatment. In addition, such an invasive unit has two ways of using a diagnostic catheter (i.e., to diagnose the patient’s case) and a therapeutic catheter (i.e., PCI). If the therapeutic catheter is unsuitable, then we send our patient to the Cardiac Surgery Unit...” (APY1).

> “This process begins from examination, investigation, and treatment to obtain more information to make a decision in diagnosing a patient’s case; however,

this process is not fixed, and it depends on the physician's experience to diagnose and treat a patient's illness" (APY3).

"In the patient treatment process, the data of a patient are accumulated from different departments such as ECG, Echo, Exercise Test, Lab Investigations, and Catheterization, then the physicians decide on the patient's case" (APY5).

"When our patient comes to the hospital, the process begins from the reception room (admission room) where the personal information about the patient is entered, and then the patient is sent to the consultation units. Furthermore, we send our patients either to the medical treatment or non-invasive units to obtain more information about the case. Thereafter, we also send our patient either to medical treatment or invasive unit to get more information that would lead to a right decision to diagnose the patient's case. Finally, we conduct either therapeutic catheterization or surgery, if necessary. Sometimes, the patient has been sent from another centre, in which case we just look at the patient's reports and depending upon the results, we provide him/her with the best treatment. The previous work is similar to a process that goes through multiple levels of units to provide good care to the patients" (BPY1).

"This process starts from the reception unit, then the consultation unit, then to the non-invasive units to obtain more information about the patient's case. Then, we send our patient either to medical treatment or to an invasive unit to obtain more information to have the right decision to diagnose our patient's case. Finally, we send our patient to the surgery unit, if the patient requires surgery" (BPY2).

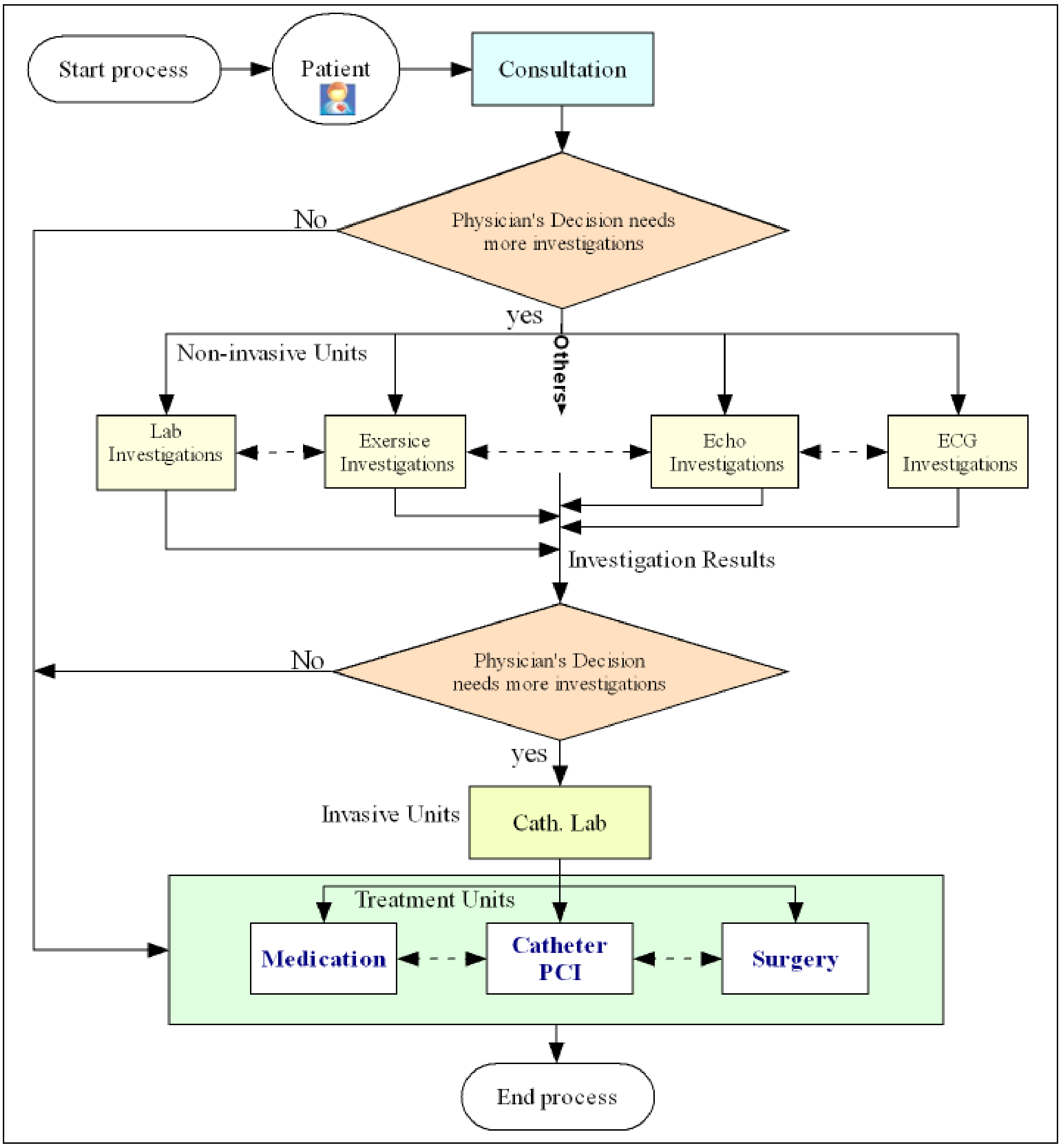


Figure 5.1 : Workflow of Physician's Activities in Patient Treatment (Flowchart)

Figure 5.1 shows the steps of patient treatment by physicians in the hospital. In the first step, the patient is sent to the consultation unit for physical examination by a physician, then the physician makes a decision on whether the patient should be sent to treatment units (e.g. medication, catheter PCI, and/or surgery) or to non-invasive units (e.g., Lab, Exercise, Echo, ECG and/or others) for further investigations. After more investigation results are obtained, the physician makes a decision either to send the patient to treatment units or to invasive units for further investigations, such as the catheter lab. Finally, the physician decides whether the patient needs treatment or not. Focusing on the patient treatment process, the steps of this process depend on the physician's decisions, which mean that the physicians in the hospital can arrive at decisions autonomously. Thus, the self-similarity and self-organization features of the fractal system characterize the cooperative healthcare system.

In the suggestions section of the questionnaire, the majority of the respondents said that the best way to enhance healthcare services in the hospitals was to establish a connection between hospital departments and/or among different hospitals to distribute new information among medical staff. Furthermore, most of them indicated that establishing and connecting R&D units among hospitals could be helpful in improving cooperation among physicians. The reason for the previous indication was that the majority of the interviewees said that the R&D unit activities could manage and control hospital activities, especially physicians' activities. According to one of the interviewees, "The activities of this unit will... organize the medical departments' management" (APY5). Another said, "This unit will improve the knowledge of researchers and physicians, and turn hospitals into trusted units through the sharing of physician activities" (APY2). The third one said, "It could help us build our knowledge and provide good care to our patients. This will be done by developing a database system that presents a global view of information for this unit. In my opinion, it is better to connect with other units from other hospitals" (APY3). The fourth respondent said, "Integrated healthcare information systems among hospitals could be very helpful in acquiring more knowledge about the best treatment and improving collaboration among medical staff" (BPY2). The fifth respondent said, "I think the main benefit of R&D unit activities is to correct information about the burden of disease in the area and to plan for managing the patient and controlling the risk factor of the disease locally, as well as to improve primary and tertiary care. Moreover, there are many other benefits that we cannot count, such as having a global view of information in this unit by connecting with others from different hospitals" (APY4). Therefore, the navigation of healthcare information as a feature of the fractal system can be helpful to improve cooperation among physicians in the same or in different hospitals.

In addition, the HIS in the hospital environment is dynamic and requires a flexible information system that can adapt quickly to any changes to gather new information and opportunities as the dynamism and vitality feature of the fractal system. With regard to this issue, some of the specialist physicians interviewed said that instances arise in which the hospital faces threats to its services and facilities. Therefore, taking internal and external opportunities is a better option by connecting the hospital with others to enable physicians to exchange new ideas with medical professionals from other institutions. For example, one of the interviewees mentioned the necessity to "try to take any new opportunities present in or outside the hospital by connecting the hospital with others to discover if there is a rare case that could be addressed, and to disseminate information that can be seen by doctors in these hospitals." The same interviewee said, "In my opinion, it is better to direct the previous tasks to an agent in the computer so that information can be obtained quickly" (APY1). With regard to this issue, another interviewee said, "We should have a teaching program for the local team and the team from other centres, but the time factor is significant for all physicians and patients. Therefore, it is important for centres to have a connection that can enable them to share the ideas and information" (BPY1). Furthermore, the researcher asked the question: When R&D activities are being developed in the hospital, would you like these activities to be managed and controlled by a group of people or by an agent-based system? The answer of the majority of the interviewees was that entrusting this mission to an agent-based system in the computer is a better option. For instance, one of the interviewees said, "To an agent, this mission should be done effectively and quickly because the time factor is important" (BPY1). The second one said, "An agent-based system is better to undertake this mission in a fast way” (APY6), and another said, “We need an expert unit as an agent to conduct all these missions” (APY4).

Furthermore, the majority of the physicians said that the sharing of information and skills among hospitals through the R&D unit can be helpful in improving knowledge and enhancing healthcare services, considering the goal orientation feature of the fractal system, such as statistical information, rare cases of patient treatment, diagnosis and therapy, and physicians’ schedules. For example, some of the answers of the specialist physicians in the interviews are as follows:

> “I think it is better to transfer the type and quantity of medical services, the new techniques in the diagnoses of patient illness, the qualifications and experience of medical staff, the results of operations, and so on… to share information on diagnoses and therapy among the medical staff, especially our doctors” (APY5).

> “In my opinion, it is better to transfer the personal, diagnostic, and therapeutic information of the patient, and transfer the results of the investigations and procedures done for the patient” (APY4).

> “Provisional diagnosis of a patient, and a final diagnosis plan for management and treatment advice are crucial because the patient may not be satisfied with our diagnosis. Then he says, ‘I will go abroad (i.e., to another centre) to take medical treatment instead of going through the surgery that you suggested’. The statistics information also need to show the results include morbidity and mortality, and the equipment used in diagnosis and intervention or surgery” (BPY1).

In conclusion, according to the development of the fractal-based information system, such a system should have fractal features. These features have been investigated in the cooperative HIS environment from the perspective of physicians in Kurdistan region, as previously mentioned in this section. The goal of this investigation was to find an open, flexible, and cooperative HIS to improve cooperation among physicians in sharing information in the hospital environment. This could lead to the enhancement of healthcare services to provide good care to patients. Some functional requirements of the development of the FHIS were extracted from the viewpoint of the physicians. The following subsection details these requirements.

5.5.1 Functional Requirements of the Physicians for the FHIS

The functional requirements of the proposed FHIS were extracted from the viewpoint of the physicians. Section B of the questionnaire provides the background information related to the HIS in the hospital. Several items in this section were extracted from requirements to overcome the healthcare system problems from the respondents' viewpoint, as shown in Table 5.8.

Table 5.8 : Descriptive Results of the Remainder Questions in the Background Information Section of Questionnaire (N=81)

Question	Response	%
10) Do you need more healthcare services from the hospitals in your town?	Yes No	79 (97.50) 02 (02.50)
11) Do you think it is important to create a system for research and development unit activities in the hospital?	Yes No	79 (97.50) 02 (02.50)
12) Do you need to navigate the healthcare information system of the hospitals in your town?	Yes No	76 (93.80) 05 (06.20)
13) Before dealing with another hospital, do you need to know what healthcare services are available there?	Yes No	77 (95.10) 04 (04.90)
14) Do you think a real-time response to your queries is important?	Yes No	79 (97.50) 02 (02.50)
15) Do you think a real-time response to any change in a system is important?	Yes No	77 (95.10) 04 (04.90)
16) Does the connection between hospitals increase the level of trust of healthcare services?	Yes No	74 (91.40) 07 (08.60)

To identify the requirements in an HIS environment, majority of the participants stated that there were numerous demands for their systems to overcome existing problems. As shown in question 10 of Table 5.8, 79 respondents (97.50%) agreed that their hospitals needed more healthcare services. To improve these services, 79 participants (97.50%)

believed this to be a key factor in creating a system for the R&D unit to control hospital activities. Moreover, 76 respondents (93.80%) wanted to know the activities of other hospitals by navigating cooperative hospital information systems. In fact, this idea was accepted by 77 respondents (95.10%). In addition, 79 (97.50%) and 77 (95.10%) participants agreed that the important matters of the R&D unit activities were real-time responses to queries and to any system changes, respectively. Furthermore, 74 physicians (91.40%) stated that the connection between these units could lead to an increased level of reliability between different hospitals.

In-depth understanding of the content of the functional requirements can be investigated based on the interviews. The specialist physicians answered several questions related to this issue. The first question was: What kind of data do you need to store in the R&D unit database? The goal of this question was to identify the elements of the database system for the R&D unit. Some answers were:

> "We need all information related to our patients and physicians. With regard to patient information, it starts from diagnoses until treatment or from admission to a hospital until discharge. For physician information, the timetable has to be put in the database system to know when and where the physicians are working to exchange patients among one another" (APY1).

> "We need all information related to patients and physicians to be saved in this unit" (APY2).

> "Patient history, clinical examinations, lab, Echo, X-ray, previous referrals to non-invasive units, then invasive unit (i.e., catheterization results), and intervention or surgery information and/or just medical treatment" (BPY1).

The next two questions were: What information do you need to transfer between hospitals with regard to improved hospital activities? What information do you need to transfer between hospitals with regard to improved quality of patient treatment? The goal of these questions was to determine the necessity of skills sharing among physicians. Some answers of the interviewees were:

> "We need to transfer specific information of a patient because in our centre, we have difficulty in managing specific types of patients, particularly in the paediatric department. Therefore, it is best to transfer the number of patients, types of treatment, results of treatment, and follow up. Furthermore, it is better to have a global perspective about the activities among hospitals;" "In our hospital, we introduce the update management of foreign teams from many countries such as the Netherlands. When these teams come to our centre, they share with us the modern treatment procedures in the surgical and medical management of patients. Also, they help us to treat the difficult cases that we did not have the experience to handle. For that, we need to transfer the information of the work of physicians on the patient treatment among hospitals to acquire new knowledge from other physicians" (BPY2).

> "All information related to the patient can be distributed among hospitals to be available to all physicians in the system. The physicians can exchange advice among each other to share their skills;" "In my opinion, we have to transfer the summary of physicians' work, the ways of treatment, and simple statistical information about patients. Furthermore, we need all information related to the patient to be transferred among physicians" (APY6).

> "We need the information on hospital units, available services, diagnostic procedures, surgical operations, field of management, and schedules of physicians" (APY4).

Another question was: When any update happens in the patient treatment process, what kind of information do you need for decision making during this process? The goal of this question was to identify ways to disseminate new procedures and rare cases of patient treatment among physicians. Following are some of the answers:

> "With regard to the historical data of a patient, sometimes we make a consultation meeting between us to discuss any new cases, and the process enables us to obtain fresh knowledge from our staff" (APY2).

> "Based on this issue, we have a discussion meeting among doctors to discuss rare cases, and the process happens with regard to having new machines, instruments, and systems as well as with a good number of professional staff to acquire more knowledge" (APY3).

> "We need the historical data of a patient to make a decision. Given a lack of doctors in our hospital, it is important to have a good database system for the sharing of information among us and with other hospitals" (APY4).

> "With regard to this issue, we have weekly meetings for all activities and cases of our patients and the new processes done by our staff" (BPY3).

An additional question was: In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities? The goal of this question was to determine the necessity of navigating the HIS to obtain correct information and check the progress. Below are some of the answers of the participants:

> "I would like to do that to obtain more information about the patient treatment to improve our knowledge and work" (BPY3).

"It is better to have it for global research, and not only for local research in our hospital" (BPY4).

"Certainly, I need to use this kind of database to get integrated information and knowledge about patient treatment, which leads to the improvement of my experience" (APY5).

The final question on this issue was: What research and development activities would you undertake in each of the following scenarios? You are given responsibility for development of your hospital healthcare services, and as coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner. The goal of this question was to determine the necessity of distributing healthcare information among medical staff within the same and in different hospitals. Some of the answers are as follows:

"To determine the budget for creating some activities in the training and updating of our staff works;" "Informing the units regularly about suggestions from medical units to directly advise the medical staff to conduct research on new topics" (APY5).

"To supply more medical units and cardiac surgeons, such as building the surgery unit in our hospital because this unit is not ready yet;" "Due to the lack of connection among hospital units, I plan to create and implement a healthcare information system among staff in this hospital and in other hospitals" (APY6).

"We need professional staff and a special unit to deal with any healthcare information development for providing a good healthcare system because there is not enough time for physicians to do everything;" "I have to disseminate new information (i.e., about new operations) in a short time to the various units for sharing among medical staff" (BPY1).

In the end, the functional requirements of the FHIS proposed in this study have been extracted from the viewpoint of the physicians who participated in this research. These functional requirements include the creation of a good HIS in the hospital for recording the patient information and the physician information and connecting these HISs among hospitals through R&D units. This idea was found satisfactory by the majority of the participants. The R&D unit in the hospital can manage and control hospital activities, especially the physician's activities in patient treatment, as indicated by the majority of the participants. Therefore, the connection among such units can disseminate these activities among physicians to improve cooperation in sharing information to improve their knowledge of patient treatment. In addition, the elements of the HIS needed by the physicians were patient information (i.e., personal information, examinations, diagnosis, and treatment) and the physician information (i.e., personal information and physician schedule). Moreover, the information among hospitals needed by the physicians included the physician's activities in patient treatment (i.e., patient details, examination results, diagnosis, and treatment of general and rare cases), the statistical information (i.e., type of patients and number of operations) and the physicians' schedules. Generally, the goal of these requirements was focused on the issue of cooperation among physicians in sharing information and skills within the same hospital and across different ones to improve the physicians' experiences.

In summary, the results of the development of cooperation in the HIS environment through the fractal-based system indicated the following:

a) The fractal features, such as self-similarity, self-organization, dynamics and vitality, navigation, and goal-orientation, have been investigated to develop an FHIS system proposed in this research. Such a system has an open, flexible, and cooperative structure to improve cooperation among physicians in sharing information and skills within the hospital environment.

b) The functional requirements of the FHIS proposed in this study were extracted from the viewpoint of the participants. The units of such a system were represented as R&D units. The connection among these units established to disseminate information among them in a timely manner. The information included the physician’s activities in patient treatment, such as obtaining patient details, conducting examinations, diagnosis and treatment, as well as statistical information and the physicians’ schedules. This work can lead to the improvement of the physician’s skills in patient treatment and the progress of research by acquiring new knowledge for other physicians within the hospital environment to provide good quality care for patients.

5.6 Discussion of Findings

The reality of conducting research in the Kurdistan region of Iraq was necessitated by the deterioration of the situation in the country and the spread of heart disease in this region. Currently, the lack of cooperation exists among physicians in sharing information and skills within the hospital environment. The findings of this study indicated that there was no and little cooperation among physicians with regard to the nine types of cooperation (with average mean = 1.994). The entire concept of the levels of cooperation among physicians with regard to the sharing of information and skills in the patient treatment was lacking, as the majority of the interviewees said. This lack of cooperation was due to the use of the healthcare system based on the manual system in most Iraqi hospitals, which makes information stored on paper difficult to manage, control, and share. Therefore, the absence of an electronic HIS has a significant impact on the cooperation level of physicians. Without a good system, new knowledge is difficult to acquire in real time, as indicated by 88.90% of the respondents. Physicians working individually in patient treatment due to the time factor and the absence of an electronic HIS also hinder cooperative initiatives. Finally, R&D unit activities are found to be weak in the Iraqi hospital environment, with 97.50% of the respondents stating that there was no unit in the hospital that helped improve procedures to make the hospital a reliable unit. Furthermore, the findings of this study on the role of the R&D unit activities in the hospital environment indicated the crucial importance of improving the cooperation among physicians to enhance healthcare services (with average mean = 4.210). Thus, the results of regression revealed that the relationship between the R&D unit activities and cooperation among physicians was $r = 0.867$, and it was significant at $p < 0.01$, which implies a positive correlation. Therefore, the establishment of R&D unit in Iraqi's hospital environment and having these units located in different hospitals but connected, it is envisage that this proposed system can promote cooperation among physicians in these different hospitals in terms of sharing information and skills in the patient treatment. In conclusion, the findings of this study indicated that cooperation among physicians in sharing information and skills in patient treatment within Iraqi's hospital environment is weak due to the following factors: (1) a large amount of data is difficult to manage and control in a manual system and a centralized database system; (2) new knowledge is not acquired in real time by the physicians; (3) physicians work independently; and (4) R&D unit activities are weak.

Aside from the previous factors, two other key factors affect the cooperation among physicians in sharing information and skills, as mentioned in the literature review in Chapter 2. Healthcare centres want to maintain autonomy, and a flexible cooperative approach is not the norm in the development of a cooperative HIS environment. Therefore, the researcher proposed a fractal-based system model to develop the cooperative HIS environment to overcome all factors mentioned previously in this section. Overcoming the previous factors, the features of the proposed system model must be more open, flexible, and cooperative than those of conventional systems. These features have been extracted from the adaptation of fractal features in the proposed system model. The fractal features are self-similarity, self-organization, dynamics and vitality, navigation, and goal- orientation. The adaptation of these features in the proposed model is based on the viewpoint of the physicians, as shown in the following:

- Self-similarity: Majority of the physicians reported that the healthcare organization system has decentralized units, such as hospitals. The structure and goal of these units are the same, especially in patient treatment. Most of the physicians also believed that the connection between similar units from different hospitals leads to the improvement of their skills and the enhancement of healthcare services. This feature is necessary to increase the flexibility of the structure and functionality between system units.
- Self-organization: Majority of participating physicians said that their hospital contains decentralized and autonomous organizational units. Focusing on the patient treatment, the hospital and physicians can arrive at decisions autonomously. The implication is that each hospital has full autonomy in the management of patient and hospital activities. This feature is necessary to provide a high level of autonomy for each unit, thus reducing global control.
- Dynamics and vitality: Given that the HIS in the hospital environment is extremely dynamic, there is a need for a flexible information system that can quickly adapt to any changes in new information and opportunities. Majority of the participants said that taking any new opportunities in or outside the hospital by connecting the hospital with others to exchange new ideas among physicians, especially with regard to patient treatment, is a better option. This feature is necessary to monitor and propagate new actions among the different units of a system environment.

- Navigation: Most of the physicians said that they need up-to-date information every time, especially in the diagnosis and treatment of patients. Therefore, the best way to enhance healthcare services in the hospitals is by establishing a connection between hospital departments and/or among different hospitals to distribute new information among medical staff. Furthermore, most of them also indicated that establishing and connecting R&D units among hospitals could be helpful in improving cooperation among physicians in sharing information. This feature leads to the better attainment of information and more efficient monitoring of progress to obtain an integrated information system.
- Goal-orientation: Given that R&D unit activities can manage and control hospital activities, especially physicians' activities in patient treatment, majority of the participants said that the sharing of information and skills through the connection of R&D units among hospitals can be helpful to improve knowledge and enhance healthcare services. This feature emphasizes the need for strategic goals to enhance decision making and the acquisition of new knowledge by the physicians.

Thus, the inspiration of the fractal features in a cooperative HIS environment, as previously mentioned, can lead an environment with numerous features, such as (1) full autonomy of each unit to execute its activities; (2) a flexible cooperative approach is the norm in its structure; (3) a large amount of data is easy to manage and control in the decentralized and autonomous organizational units database systems; (4) new knowledge is acquired in real time by the physicians in the hospital environment; (5) the physicians can work independently but cooperatively by exchanging skills in patient treatment; and (6) the connection of the R&D unit activities among hospitals can improve these activities and cooperation among physicians in sharing information and physician skills in patient treatment within the same hospital and across different ones.

For instance, the dissemination of information among hospitals involves the physician's activities in patient treatment, including patient details, examinations, diagnosis and treatment, statistical information, and the physicians' schedule. This work can help improve the physician's treatment skills and the progress of research by acquiring new knowledge for other physicians to provide good quality care to patients.

In summary, cooperative HISs can only perform fractal functions if they possess self-similarity, self-organization, dynamics and vitality, navigation, and goal-orientation features. The fractal features have been used successfully to provide a flexible structure and a concrete cooperative system to represent each unit in the system as fractal units. Cooperation among fractal units is also a major factor to help the fractal-based information system attain the system goal, improve member qualifications by sharing new knowledge in a speedy manner, and satisfy system requirements. Therefore, participating healthcare professionals strongly believe that developing HISs based on the fractal potential can provide numerous benefits to healthcare centres, such as increased cooperation among physicians in sharing information. This cooperation in turn leads to the improvement of physicians' experiences and the satisfaction of most system requirements through the exchange of information between system units (i.e., R&D units) as R&D agents. Furthermore, physicians' skills improvement leads to enhanced healthcare services.

5.7 Summary

The participants in this study were 100 physicians from two government hospitals (the Hospital A and the Hospital B) in the Kurdistan region of Iraq. These participants were hospital managers, doctors, senior house officers, intervention cardiologists, and cardiac surgeons. These two hospitals participated as case studies to address the research question in the real environment. The mixed methods approach was used in this study to address the research problem. In such an approach, both the questionnaire and interview techniques were used in a complementary manner to guide the researcher in the data analysis and discussion of findings.

The study found that the cooperation among physicians in sharing information and skills related to patient treatment in Iraqi's hospital environment is weak (see Table 5.2) due to the following factors:

- There is a large amount of data that is difficult to manage and control in a manual system and a centralized database system.
- New knowledge is not acquired in real time by the physicians within the hospital environment.
- Physicians work independently.
- R&D unit activities in the hospital environment are weak.

Moreover, this study established a positive relationship between R&D unit activities and cooperation among physicians, that is, the improvement of R&D unit activities can improve cooperation among physicians in sharing information. Two other important factors affecting such cooperation among physicians were extracted from the literature. Specifically, healthcare centres wish to maintain autonomy, and a flexible cooperative approach is not the norm in the development of a cooperative HIS environment.

The next indicator of the study findings is that fractal features can be adapted in a cooperative HIS environment to develop efficient cooperative HISs as in the fractal approach. This approach has been used successfully in several studies to address the lack of flexibility in systems in terms of reacting to internal and/or external requirements, as well as to facilitate the achievement of cooperation among system units. Therefore, the following main features of the fractal approach have been adapted:

self-organization, self-similarity, dynamics and vitality, navigation, and goal-orientation. The goals of the adaptation are as follows:

- The self-similarity feature is adapted to increase the flexibility of the structure and functionality between HIS units;
- The self-organization feature is adapted to provide a high degree of autonomy for each unit and to decrease global control;
- The dynamics and vitality feature is adapted to monitor and propagate new actions among HIS units;
- The navigation feature is adapted to gain information and check progress to obtain an integrated information system; and
- The goal-orientation feature is adapted to achieve the strategic goals of the system and enhance decision making by the physicians.

The aforementioned goals can be instrumental in efficiently cultivating the style of cooperation between physicians in sharing information and skills related to patient treatment. This work can lead to the improvement of the physicians' experiences by enabling them to acquire new knowledge from others, which in turn leads to the enhancement of healthcare services in the hospital environment. The importance of this cooperation also lies in the importance of the system goals to provide good quality care.

The steps of developing and evaluating the proposed FHIS model are discussed in greater detail in the following chapter.

CHAPTER 6
SYSTEM DEVELOPMENT AND EVALUATION

6.1 Introduction

This chapter has three parts. In the first part, the design and implementation of a fractal-based healthcare information system (FHIS) model are presented, including a description of the development platform and the use of various modules. In the second part, the FHIS is evaluated by a testing procedure and then by potential users from the participated hospitals (Hospital A, Hospital B), followed by an analysis of the questionnaire and the semi-structured interview responses of selected physicians who tried out FHIS. The last part reflects on the findings of the analysis and suggests appropriate actions for fine-tuning FHIS.

6.2 Development platform of the FHIS

The development of FHIS includes the following processes: design (see section 6.2.1), test (see section 6.3), implement (see section 6.2.3) and evaluate (see section 6.4).The FHIS model is proposed to provide an integrated cooperative HIS environment that will improve cooperation among physicians in terms of sharing information and skills in patient treatment within the hospital environment. This model is also aimed at improving the skills of physicians, which will lead to enhanced healthcare services. The FHIS is developed based on the fractal theory and its features that link system units (see Figure 2.13 in Chapter 2). Such system is selected to provide an appropriate, open, autonomic, flexible, and cooperative system environment. The FHIS consists of decentralized and autonomous process units that retrieve and update data to provide necessary information to physicians. Therefore, the FHIS is designed based on web applications to manage and control healthcare information and to quickly and accurately disseminate this information among physicians within the same hospital and between different ones.

6.2.1 Design of FHIS

The design of the FHIS is based on the fractal theory and its features (e.g., self-similarity, self-organization, dynamics and vitality, navigation and goal-orientation) to continuously provide changes and updates in structure and information depending on the system's environmental requirements (Kirikova, 2008; Tharumarajah, et al., 1998; Warnecke, 1993). Such a system consisted of decentralized and autonomous process units (i.e., Fractals) that retrieve and update data to provide the necessary knowledge and information. The units of FHIS involved same modules (see Figure 2.13 in Chapter 2). Additionally, the proposed FHIS has been developed using an agent-based technique to represent FHIS units as agents. These agents were involved as a component of software that possesses autonomy and intelligence, and capability of communications and cooperation with other agents to accomplish functions among system units as fractal units. The agent-based technique was also used because it is more suitable in the development of such systems (Leitão & Restivo, 1999; Parunak, 2000). The subsequent sections explain the system structure and programming tools used to develop the proposed system.

6.2.1.1 Construction of the FHIS

The development of most of distributed HISs applications were conducted with a Web-based application to easily manage and control the healthcare information, and allow users to access their information and exchange their skills with others based on the user privileges (Erdil, 2009). Given that a Web-based application is a tool for aggregating applications online, it typically offers a wide range of information content, applications, and services, integrated into a single-theme interface that is easy to navigate, reflects the interests of different users, and enables them to access information from multiple sources.

The FHIS was designed based on Web applications to manage and control healthcare information, and quickly and accurately disseminate this information among medical staff, especially physicians. The FHIS construction is shown in Figure 6.1.

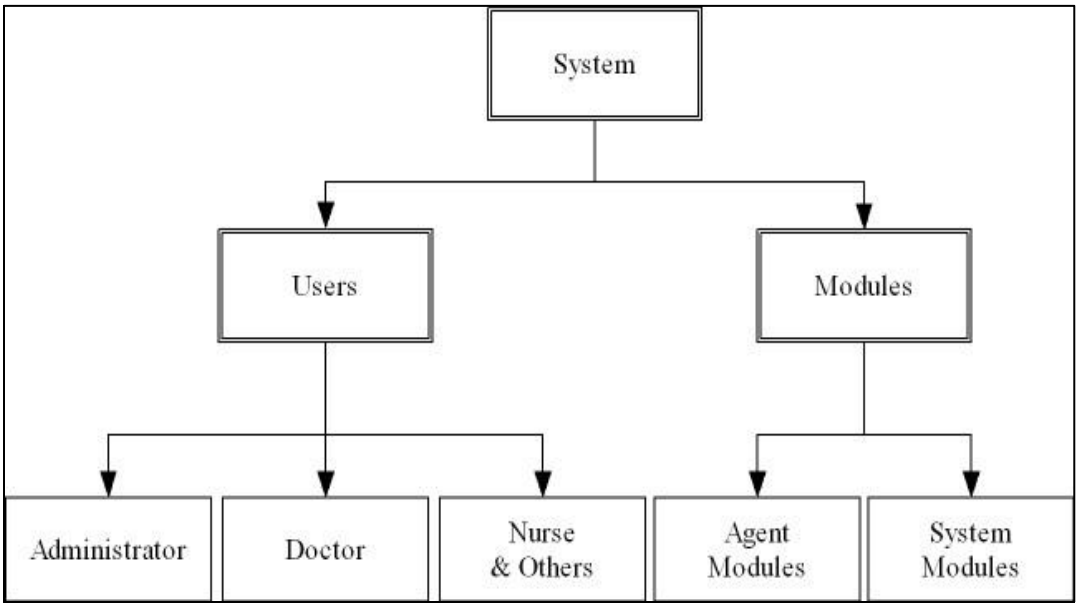


Figure 6.1: Construction of the FHIS

Figure 6.1 illustrates the combination that acts as the entire FHIS, which involves modules and users. The system modules are used for data entry and providing information and knowledge for users in interfaces, and agent modules used in creating and storing information in real time and then disseminating it among FHIS units (i.e., agents) to facilitate the treatment of patients. The users are administrators, doctors, nurses, and other persons who have the responsibility and privilege to enter and view healthcare information.

From the perspective of information communication technology (ICT), the FHIS construction was developed on the basis of an agent-based technique to link the FHIS units in different hospitals as fractal units using Web-based application tools. The general structure of the FHIS is depicted in Figure 6.2.

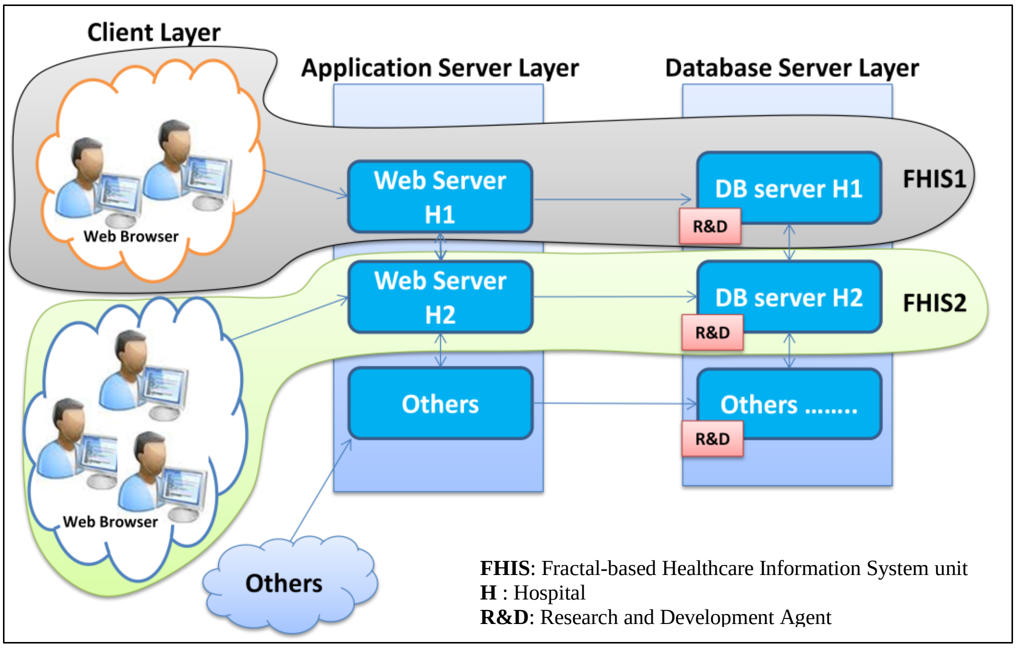


Figure 6.2: The General Structure of FHIS

In Figure 6.2, the FHIS structure contains three layers of applications in each hospital represented as fractal units (i.e., FHIS units). The first is the Database Server Layer, which involves a database and knowledge-based management system, and R&D agent modules. Next is the Application Server Layer, which involves a Web server to provide user interfaces as Web pages for entering, displaying, and sharing of information on the internet among medical staff. The last is the Client Layer involved in the use of any Web browser (e.g., Internet Explorer, Mozilla Firefox, Netscape, Google Chrome, and Opera) by users to navigate the system Web pages to share healthcare information in the same or in different hospitals.

6.2.1.2 Programming Tools Used to Develop the FHIS

The development tools for the FHIS comprise Oracle applications, including Oracle Database, HTML, SQL, PL/SQL, Java, CSS, and BI Publisher. The core modules of the

FHIS take several phases to develop and implement. The FHIS is a web-based application and therefore needs a three-tier architecture composed of database, application, and client layers (see Figure 6.2). Using Oracle application tools facilitates the implementation of web-based information sharing and provides a flexible updating environment under an independent platform (Koletzke & Mills, 2007). In the Database Server Layer of the FHIS, the Oracle Database Enterprise Edition software was used to create such a layer. In this layer, the SQL tool was used to design a database and knowledge base, whereas the PL/SQL tool was used to create R&D agent modules and their operations. In the Application Server Layer of the FHIS, the Oracle JDeveloper software was used to create a Web server and develop a Web application to provide user interfaces as Web pages. Applications developed with JDeveloper work with any data source and can be deployed on any J2EE-compatible application server. In the Client Layer of the FHIS, no software was needed to install only Web browsers in the client site. In this site, the users can use any Web browser to navigate the system Web pages provided by the Application Server Layer of the FHIS. Given that the FHIS system is a Web-based application, the users can navigate the system from anywhere depending on their privileges.

6.2.1.3 Development of Functional Requirements for the FHIS

The functional requirements (see section 5.5.1 in Chapter 5) for the FHIS are detailed in this section to explain the system function and details of the system requirement specifications. These functional requirements depend on the physicians' requirements from the data collection in sharing information and skills in patient treatment in the hospital environment. The requirements are also based on the operations of fractal features, as use cases, to exchange information among system units. The operations of fractal features in the FHIS are explained later in this section.

Aside from the functional requirements, other requirements have to be considered, such as the integrity, security, flexibility, and maintainability of the FHIS system.

The integrity of the system is necessary to prevent any mistake or error that may occur on the part of the users or operators while using the system. The key points in the integrity process of the FHIS system were verified and checked during the stages of patient treatment. After ensuring that the patient treatment is successful, the doctors and nurses update the patient treatment status to disseminate the information among the physicians. This dissemination process is automatically managed and controlled by the R&D modules of the FHIS system. This integrity process aims to prevent any error that may occur in the encoding of the patient treatment information and in disseminating such information as knowledge among system units.

A security process of the system was important to prevent unauthorized users from accessing any part of the system. The system users have usernames and passwords provided by an authorized person (administrator) to enable them to access the system. Users without such authorization cannot access the system. This process is intended to prevent any problem caused by illegal users. Furthermore, even if the users have usernames and passwords, they have limited authorization, which means that each user has a special privilege based on job level (doctor, nurse, admin, and so on).

A flexibility process is essential to the FHIS system due to the development of such a system based on the fractal theory and its features as well as the system's environmental requirements, especially physicians' requirements in the cooperation issues. Therefore, such a system can be adapted to any new requirements because the system is open, distributed, autonomic, flexible, and cooperative. Moreover, the system units are isolated from one another as fractal units. Thus, the system units can be added, upgraded, and modified in a flexible manner based on the requirements.

A maintainability process is crucial to the FHIS system, which has the ability to modify and/or correct the system performance to improve it. Given the FHIS system development based on the fractal approach, the units of such a system have freedom in the organization and implementation functions. Hence, the system can support maintainability by adapting to changes in the system environment without challenging the formal structure of the organization and the system functions.

The detailed architecture of the development of FHIS is shown in Figure 6.3. In this Figure, the requirements based on the operations of fractal features are explained to exchange information among system units. Figure 6.3 describes the architecture of the FHIS. Each hospital has a similar unit also called the FHIS, which serves as fractal unit that investigates the self-similarity feature of fractal. Each unit has full autonomy to execute activities in the system to represent the self-organization feature of fractal. The FHIS unit can monitor and propagate new activities within the same FHIS and between different FHISs, which is a dynamic and vitality feature of this unit. Each FHIS has a navigation feature that allows physicians to acquire information and check patient progress within the hospital environment. This feature can coordinate FHISs to obtain a goal-oriented feature, an act of acquiring new knowledge by physicians. Furthermore, agent-based techniques are employed to develop a fractal-based system to investigate such fractal features. Such techniques are likewise utilized in the proposed FHIS to represent FHIS units as agents called research and development (R&D) agents. The physicians can use such agents to manage and control their activities in patient treatment and accurately disseminate such activities as new information among physicians to acquire new knowledge in a timely manner. Each R&D agent has the same modules, such as the Controller (C), Analyzer and Planer (A&P), Executer (E), and Knowledge-base and Database (KB&DB) modules, to represent the previous management process and to control the activities of physicians. The following sections explain the function of each module for the R&D agent and describe how various modules in the FHIS interface are utilized.

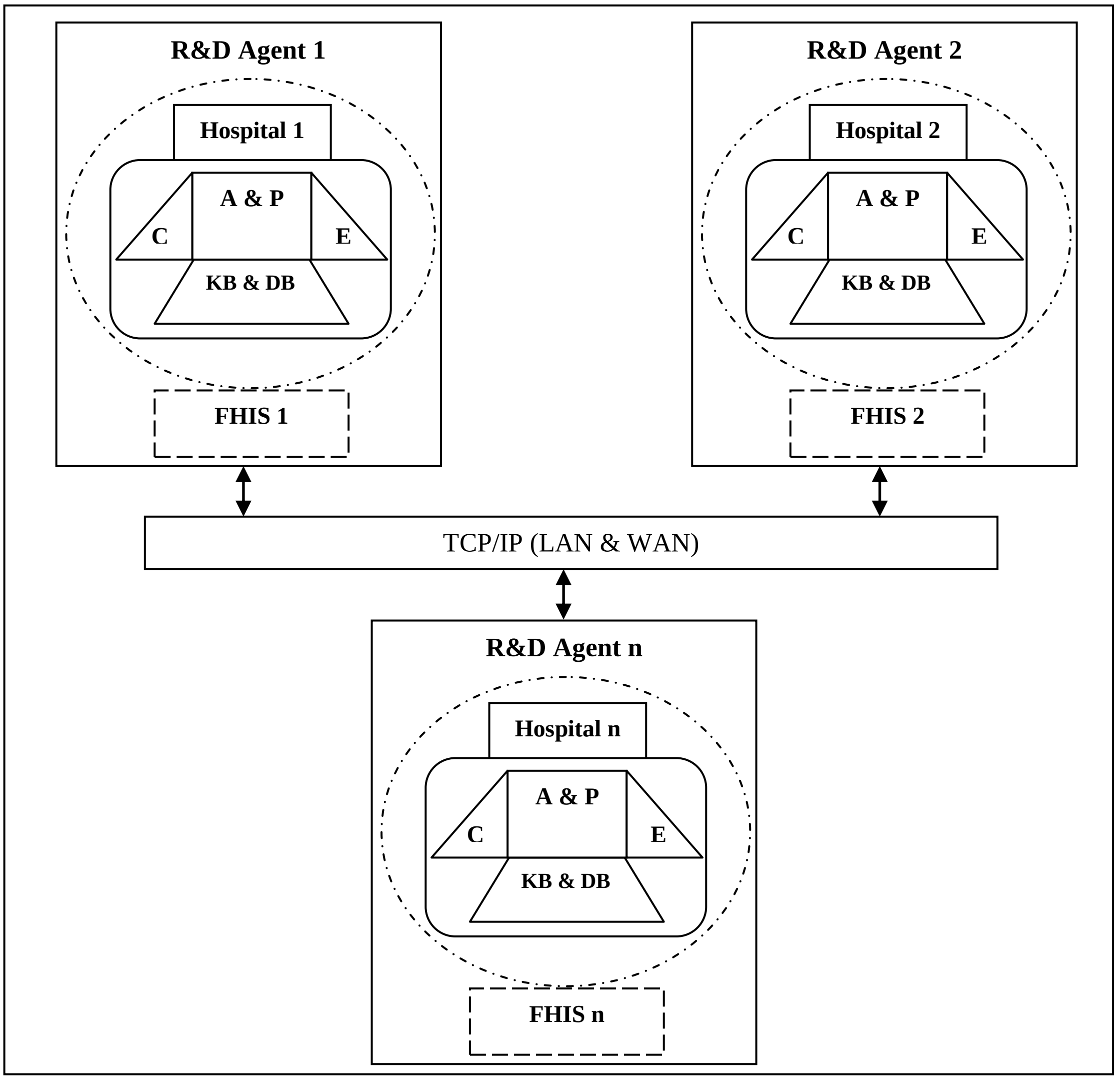


Figure 6.3: Architecture of the FHIS

6.2.2 R&D Agent Modules and Their Functions

The FHIS modules of R&D agents (see Figure 6.3) are developed to manage and control new activities of inner and outer agents and to share such activities as information to physicians in real time. This timely exchange improves cooperation among physicians, which will in turn improve their skills in providing good quality care for patients and enhance healthcare services within the hospital environment. Information and knowledge sharing among physicians is achieved from the viewpoint of participating physicians themselves and their patient treatment activities (see section 5.5.1 in Chapter 5). The information includes the patient treatment activities of physicians, such as patient information gathering, examinations, diagnosis and treatment of rare cases, statistical information manipulation, and scheduling. The functional modules and relationships of an R&D agent are shown in Figure 6.4 as use case modelling, which facilitates system module development. Such modelling describes the requirements, functions, and relationships of system modules (Whitten & Bentley, 2007).

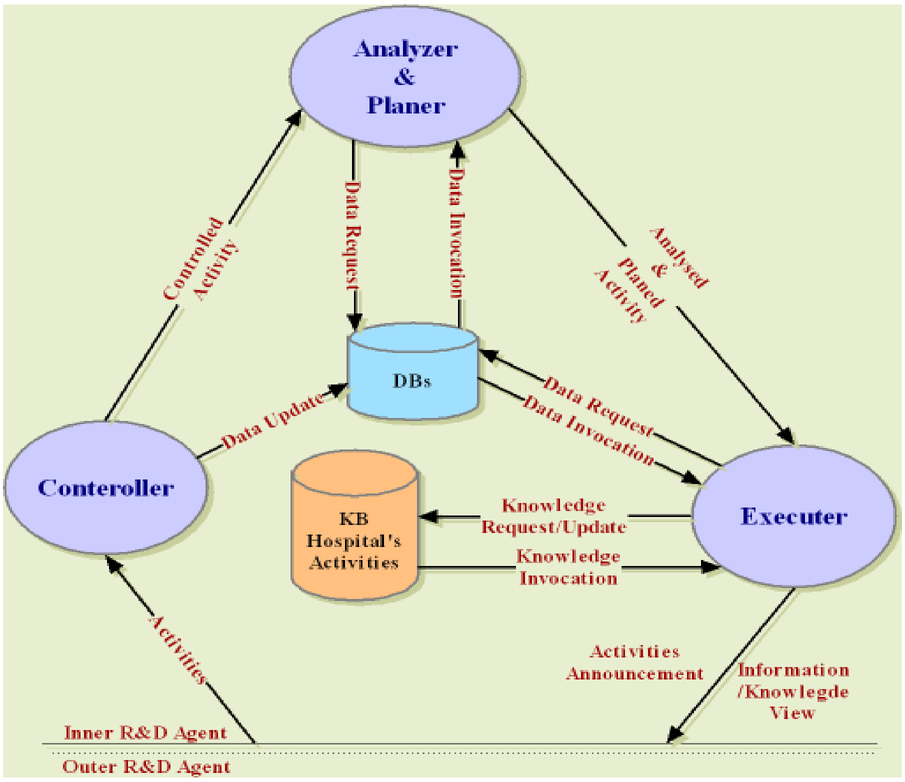


Figure 6.4: Functional Modules and Relationships of the R&D Agent

6.2.2.1 Knowledge-base and Database (KB&DB) Module

The KB&DB module in Figure 6.4 is represented as a repository of data related to hospital healthcare information. The module is divided into two parts: 1) The first part pertains to the KB of hospital activities. Its function is to manage and record hospital activities, especially the patient treatment activities of physicians. 2) The second part pertains to hospital DBs, which contain information such as patient and physician records as well as physicians' schedules. The function of this part is to manage and record data related to the hospital's healthcare information.

In this study, healthcare information related to the cardiac centre, which includes the patient treatment activities of physicians is reviewed to create data entities (i.e., tables) of the KB&DB module. The Oracle database management system is used to manage these entities successfully as a relational database. An entity relationship diagram (ERD) of a data model is a detailed logical representation of data for a database in a system. The ERD model is expressed in terms of entities in an environment and the relationship among the entities as well as their attributes. The conversion of a logical data model to a physical data model is called a database schema (Satzinger, Jackson, & Burd, 2012; Whitten & Bentley, 2007). Figure 6.5 shows the ERD of the database schema for the DB part. The ERD of the database schema for the KB part is depicted in Figure 6.6. These diagrams document the relationship represented in database processing. More information on tables and their attributes is tabulated in Appendix G.

The patient information has been saved in DB part of the KB&DB module. Physicians' activities in patient treatment have been saved as knowledge in KB part of the KB&DB module. The process of sharing of patient information and physicians' activities between DB and KB and providing this information in the FHIS interfaces can be managed and controlled by other modules of the R&D agent. The following subsections are detailed the previous aforementioned process.

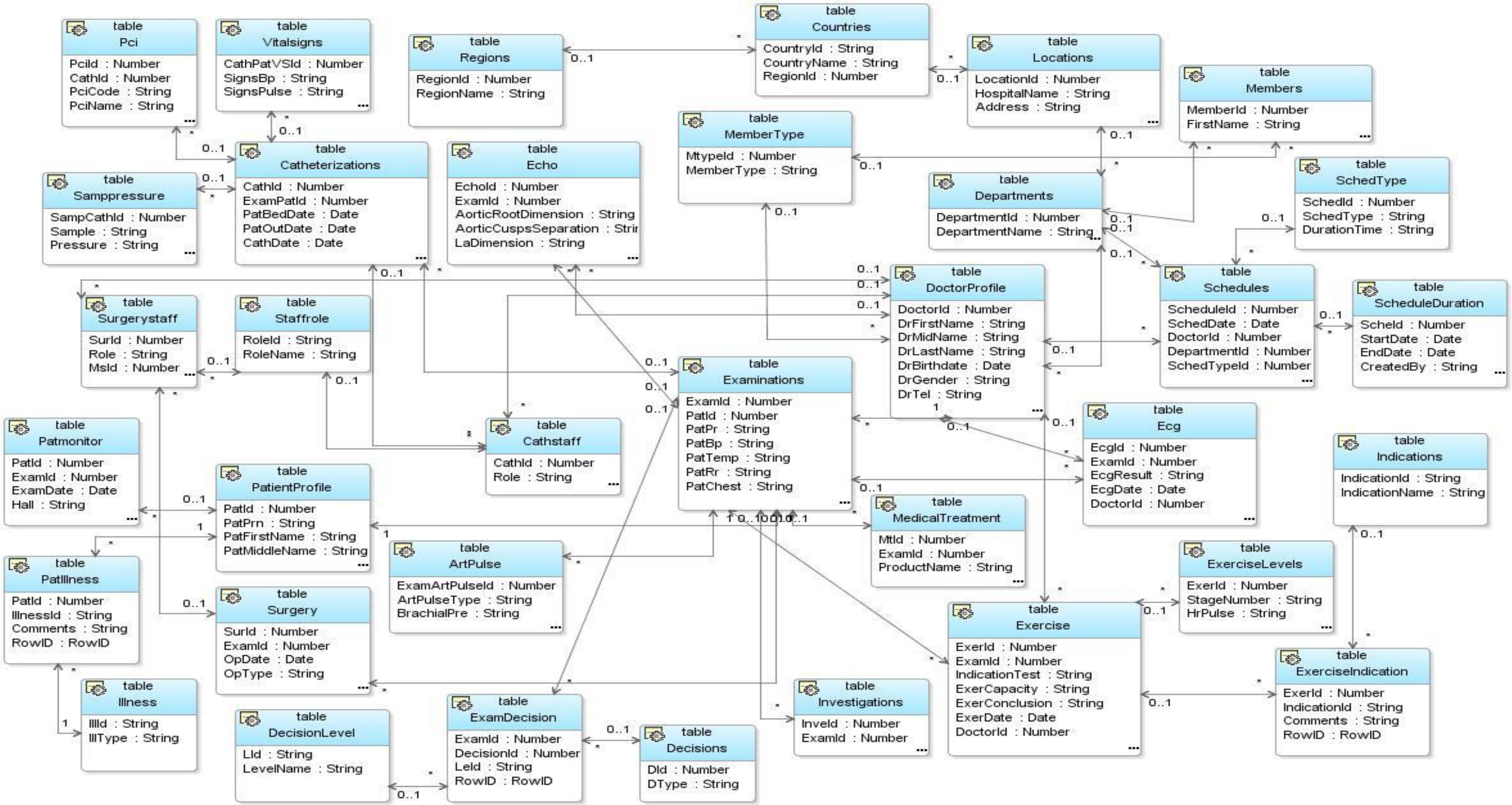


Figure 6.5: ERD of the Database Schema for DB Part

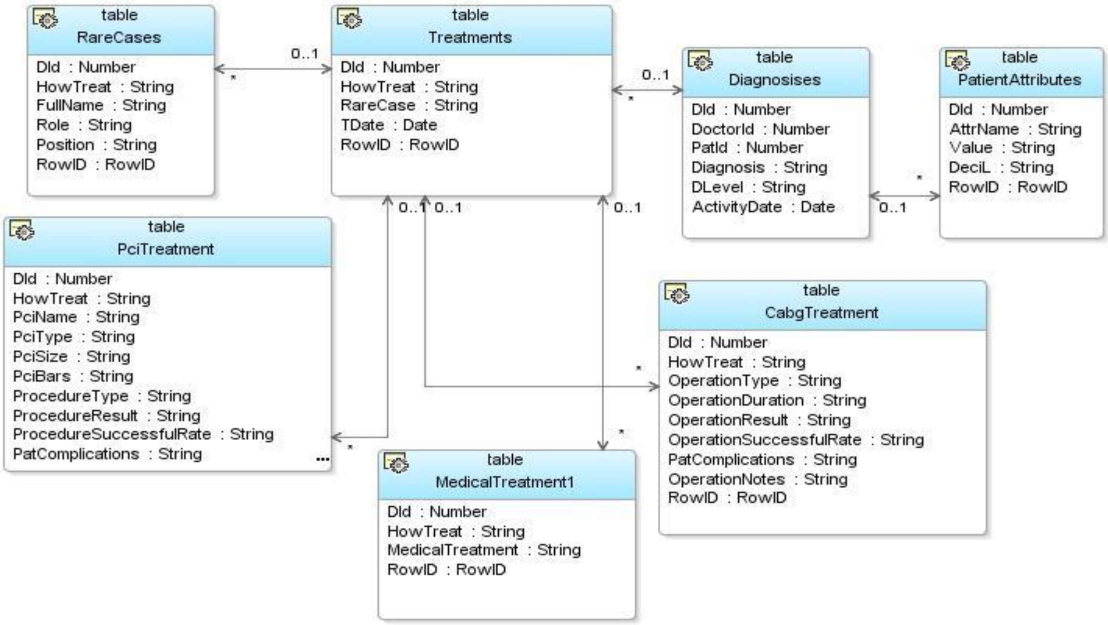


Figure 6.6: ERD of the Database Schema for KB Part

6.2.2.2 Controller (C) Module

The C module of the R&D agent (see Figure 6.4) monitors the patient treatment activities of physicians within an inner and outer agent. The workflow of these activities is shown in Figure 5.1, Chapter 5. The function of the C module is to monitor a new activity, such as the complete patient treatment process, the creation of new schedules of physicians, and the change of statistical information. When any of these new activities are initiated or triggered by the users in a system, the C module automatically sends a message about the new activity, as a controlled activity, to the A&P module to analyze such activity as either an inner or outer R&D agent. The trigger concept of database objects is used to represent such function, and pseudo code is frequently used to represent the logic of each module. The pseudo code for this module is provided in Appendix G.

6.2.2.3 Analyzer and Planer (A&P) Module

The A&P module of the R&D agent (see Figure 6.4) analyzes a new activity received from the C module by considering its nature—inner or outer. If the new activity is characterized as an inner one, the A&P module describes the type of activity and plans which data are related to the activity by navigating the DB of the KB&DB module, with the aim of announcing the E module of the data related to this new activity. For instance, when the type of activity is a complete patient treatment process, the A&P module checks the status of the patient and a final diagnosis of the patient's illness is completed. Then, this module checks the level of final diagnosis, namely, consultation, non-invasive, or invasive level (see Figure 5.1 in Chapter 5). Next, the A&P module checks the types of treatment undergone by the patient, namely, medical and/or operation treatment. Finally, this module will check whether the treatment process is succeeded or whether it is a rare case (i.e. new case) through checking the information of the patient treatment case field from the DB part of the KB&DB module. The functions of the A&P module in the previous instance is to identify integrated data related to the patient treatment activity of a particular physician and to send a message to the E module to fetch all data related to that particular activity from the DB part of the KB&DB module. Other types of activities include the creation of new schedules of physicians and changes in statistical information (e.g., number of patients in terms of gender, mortality, and number of operations performed per month). If the new activity is characterized as an outer one, the A&P module obtains details of this activity from outer R&D agents through the C module. Such details contain the type of activity, the name of the agent, and link information. Then, the A&P module sends these details to the E module to create a link to this outer activity and view related information locally. The package and procedure concept of database objects is used to represent the function of the A&P module for all previous types of activities. The pseudo code for this module is provided in Appendix G.

6.2.2.4 Executer Module (E)

The E module of the R&D agent (see Figure 6.4) initiates their function upon receiving an announcement from the A&P module, which categorizes an activity as an inner or outer one. When this announced activity is characterized as an inner one, the E module obtains complete data of this activity by navigating the DB part of the local KB&DB module using the mechanism of data request and invocation. Then, the E module saves the data as knowledge in the KB part of the same module. Afterwards, the E module sends the announcement about the new activity as new knowledge to other FHIS units (i.e., R&D agents) in the system. If the activity comes from an outer agent, the E module creates a view for this new activity. By using this mechanism in propagating new activities as new knowledge among FHIS units of the system, physicians in each unit can be supported by providing them with efficient information related to their job. Acquiring new knowledge in real time at any given time will consequently improve the performance of the physicians. The procedure concept of database objects is used to represent the function of the E module for the previous types of activities. The pseudo code for this module is provided in Appendix G. Information sharing among physicians within the same hospital and between different ones can be utilized by using FHIS interfaces, which are discussed in the following section.

6.2.3 FHIS Interface Modules and Their Functions

The FHIS interface modules and their functions are depicted in Figure 6.7 as a use case diagram.

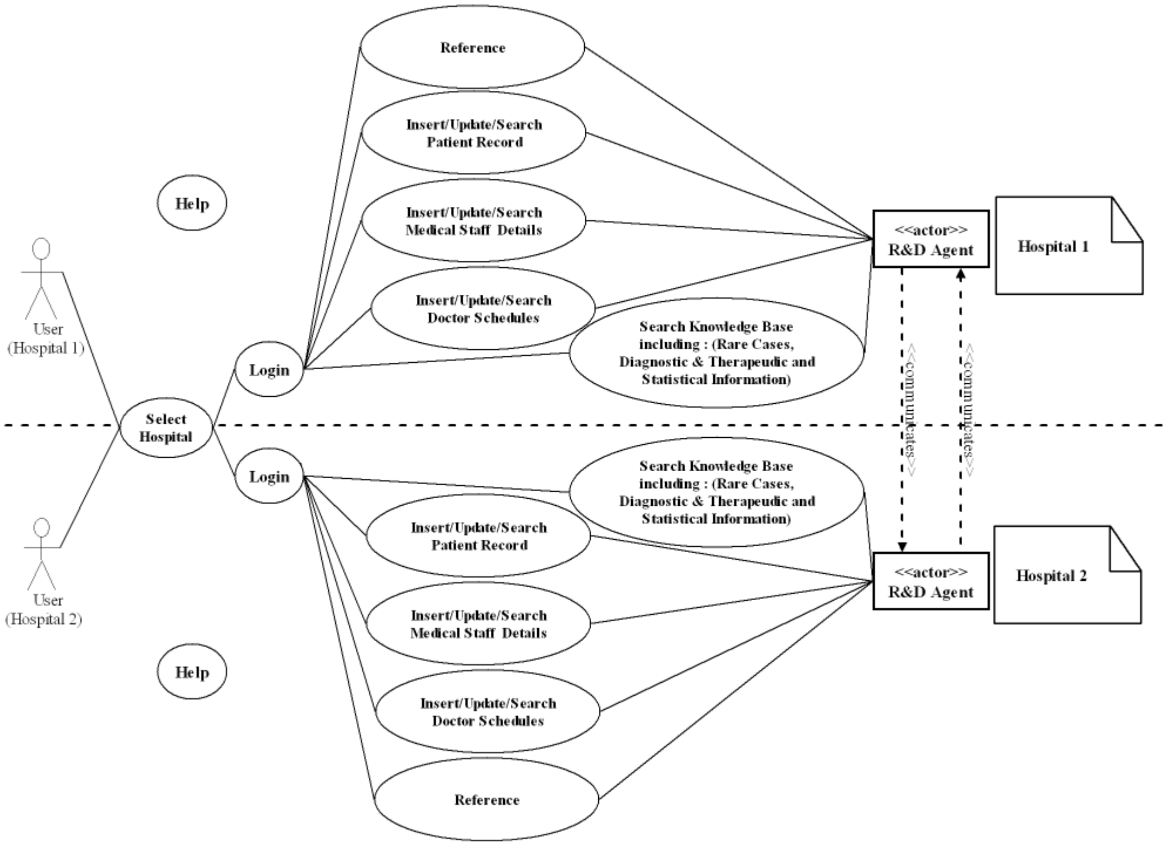


Figure 6.7: Use Case Diagram of Functional Modules of FHIS Interface

In Figure 6.7, the use case diagram describes the functional modules of the FHIS interface through user (e.g., administrator, physician, and nurse) navigation from different hospitals. In the first, a physician selects the name of the hospital in which he/she operates and logs into the system locally. The FHIS provides information for physicians depending on the authentication and authorization characteristics of the security service. In the security issue, the administrator, manager, and user are used as the user roles to access information in the FHIS. Such system comprises patient records, medical staff records, doctor schedules, knowledge base and reference information. The physician can navigate the system to see patient information, schedule, and patient treatment activities locally. The user can also see the activities of other physicians within the same hospital and between different ones through the R&D agents. This use case diagram is tested among two participant hospitals (Hospital A and Hospital B) of this study. Table 6.1 summarizes the functions of the main modules of the FHIS interface. The interface of some main modules is detailed in the following subsections. The rest of the modules are summarized in Appendix G.

Table 6.1: Functions of the FHIS Interface Modules

No	Interface Module Name	Functions
1	Select Hospital Name	o The user most select the name of the hospitals in which it operates to login.
2	Login	o To validate the user to ensure authorized access to the FHIS. Thus, when a user tries to log in, the system will check the authenticity and authority of the user in the local web server.
3	Medical Staff	o This module allows the user to insert, update and/or search the healthcare practitioners especially the physicians' details based on their privileges.
4	Patient Record	o This module displays patient records. The user can insert, update and/or search on the particular patient based on their privileges.
5	Doctor Schedules	o This module allows the doctors to see their schedules per month and to see other doctors' schedules from different hospitals. The user can insert, update and search doctor schedules based on their privileges.
6	Knowledge Base	o This module allows the doctor to view the rare cases of the patient treatment, the diagnostic and therapeutic of the patient case, the statistical information of the hospital and other hospitals.
7	Reference	o This module allows the user how have an administrator privilege to insert or update the particular data to use such data in the previous modules.
8	other modules	o Assistant module called "Help". This module helps the user how to navigate and use the FHIS. o Logout module logs the user out of the FHIS.

6.2.3.1 Interface

Interface design plays a crucial role in the development of the FHIS. The goal is to make data entry logical and navigation easy. Figure 6.8 shows the interface layout of the main page of the FHIS, where one can select the hospital name and press the *login* button. The interface layout of the login page checks the authenticity and authority of the user in the local web server (see Appendix G). All particular modules implemented in the FHIS are viewed by the user in the interface layout of the home page based on the authority of that user.

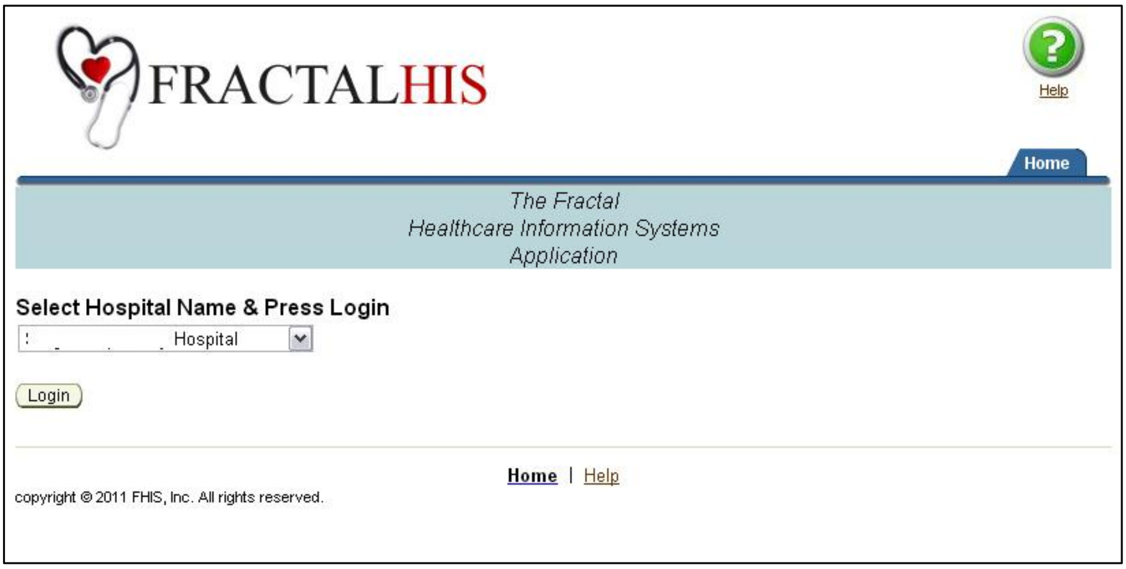


Figure 6.8: Interface Layout of Main Page

6.2.3.2 User View

The FHIS provides eight main modules for the user: *Home, Medical Staff, Patient Record*, *Doctor Schedules, Knowledge Base, Reference, Help, and Logout*. The users, such as administrators, physicians, and nurses, need to move from one module to another to obtain particular information. In terms of user role, the user who has an administrator role can access all main modules; the user who has managerial and other roles can only access the seven main modules (see Figures 6.9). All modules in the user's view are explained clearly in the following subsections.

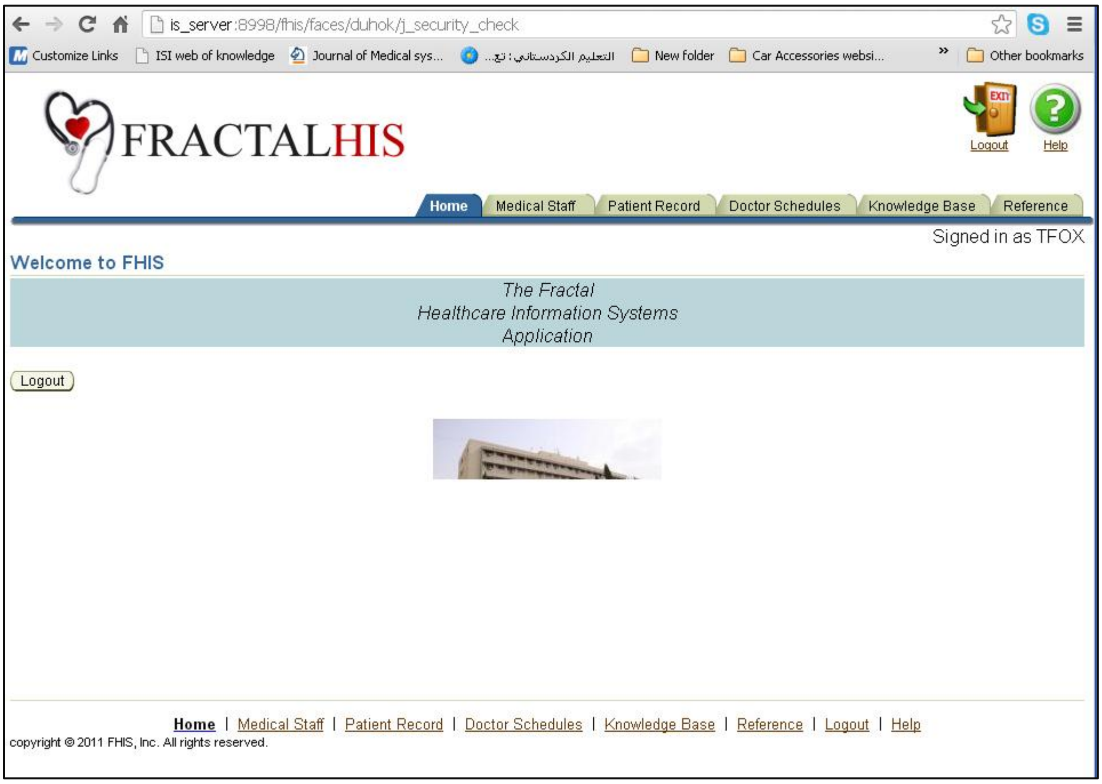


Figure 6.9: Home Module of the FHIS

Home Module

Figure 6.9 provides a screenshot view of the home module of each hospital in the FHIS. The name of the application system and the picture of the hospital are also provided. The user can see his/her name upon logging into the system successfully, as mentioned in the message (e.g., signed in as TFOX) found on the right side of the home page, right under the tabs of the module name. From the home module, the user can obtain the hospital address and navigate all modules of the FHIS depending on his/her privileges by pressing the tab of the module name.

Medical Staff Module

Once the user logs into the system, the user can readily navigate the page to update and view information. Figures 6.10 provides a screenshot view of the medical staff module, wherein users can insert, update, and search medical staff information within the same hospital based on their privileges. First, the user presses a *new staff* button if the intended operation is to insert details about new medical staff. If the user wants to search for medical staff information, he/she needs to enter pertinent information in the search form. At least one of the boxes should be filled out to perform the information search; if the user does not fill out all the boxes, the system displays the information on all medical staff available in the hospital system. When the search results are shown, the user can edit or delete information depending on his/her privileges.

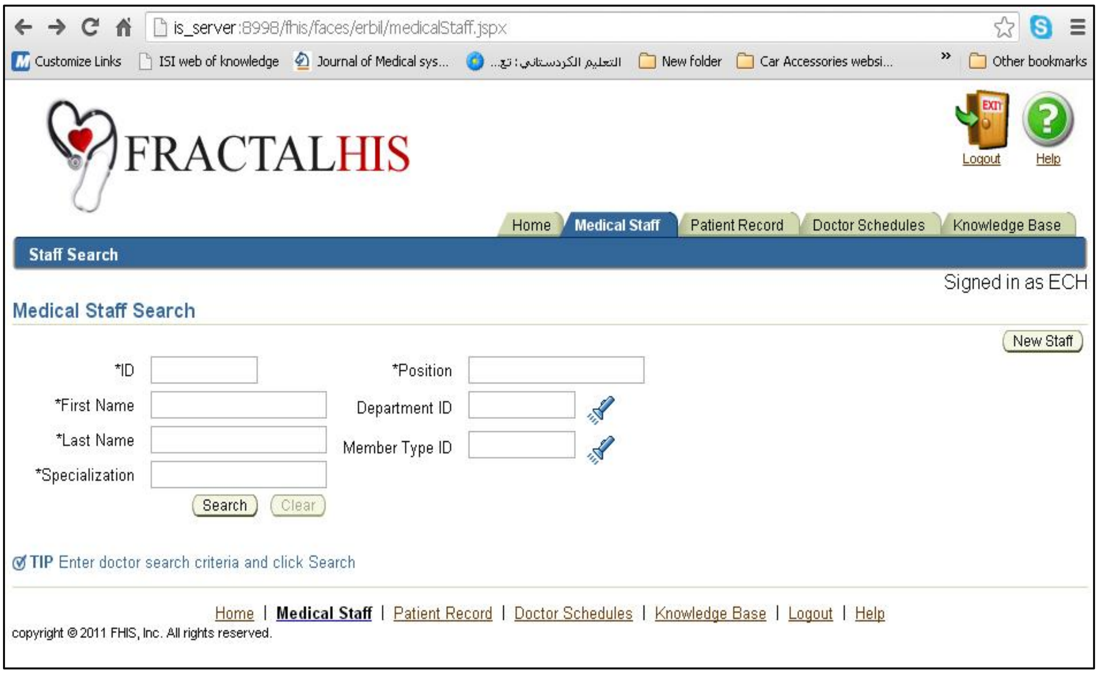


Figure 6.10: Medical Staff Module of the FHIS

Patient Record Module

The user who logs into the FHIS can access patient information within the hospital. Figure 6.11 provides a screenshot view of the patient record module, wherein users can insert, update, and search patient information based on their privileges. First, the user presses a *new patient* button if the intended operation is to update patient information. If the user wants to search for a particular patient, he/she needs to enter pertinent information about the patient in the search form. At least one of the boxes should be filled out to perform the information search; if the user does not fill out all boxes, the system displays the information on all patients available in the hospital system. When the search results are shown, the user can then view and update particular patient information depending on his/her privileges.

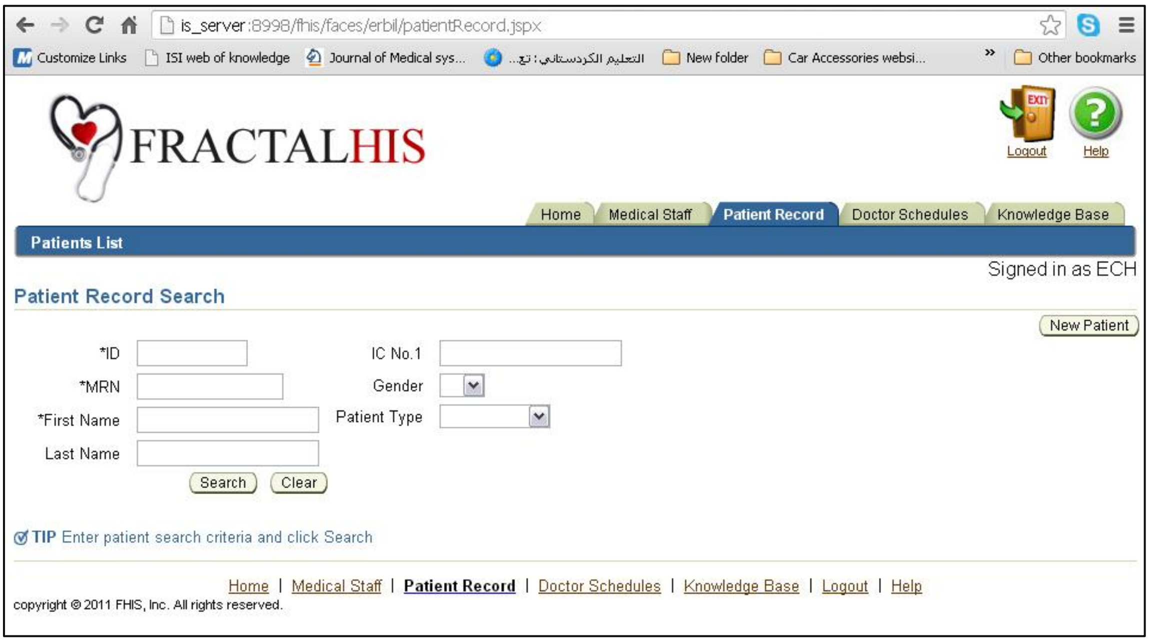


Figure 6.11: Patient Record Module of the FHIS

Doctor Schedules Module

The user who logs into the FHIS can further navigate doctors' schedules within the same hospital and between different ones. Figures 6.12 and 6.13 show doctors' schedules before and after pressing a *search* button in the doctor schedule module. The user can view and edit information related to the doctor's monthly schedule in the hospital, including details pertaining to the time of work of each doctor and the department in which they are assigned. In such a module, the user can also view the details of the schedules of doctors from other hospitals. Such access allows the user to contact other doctors to share patient information by clicking a subtab for other hospital schedules on the page of the same module.

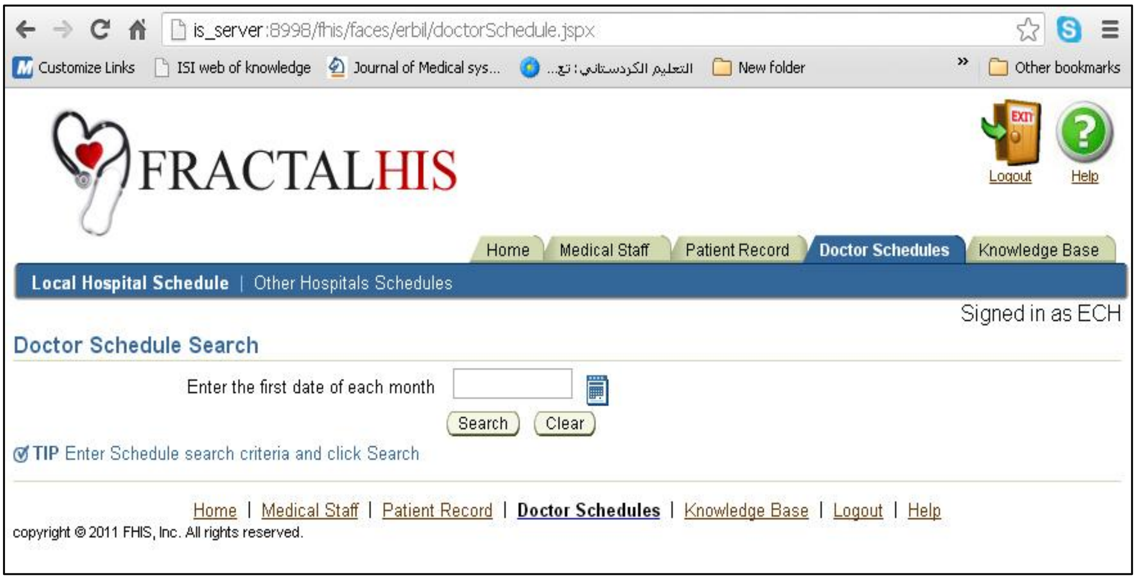


Figure 6.12: Doctor Schedules Module before Searching

Figure 6.13: Doctor Schedules Module after Searching

Knowledge Base Module

The page of the knowledge base module allows the user to search for patient treatments by physicians within the same hospital and between different ones as well as to access statistical information. This module is an important element of the FHIS, as it facilitates cooperation among physicians with regard to real-time sharing of information and skill in patient treatment. Figure 6.14 shows details of patient treatment for rare cases, which are displayed by clicking the Knowledge Base tab and pressing the *Search* button.

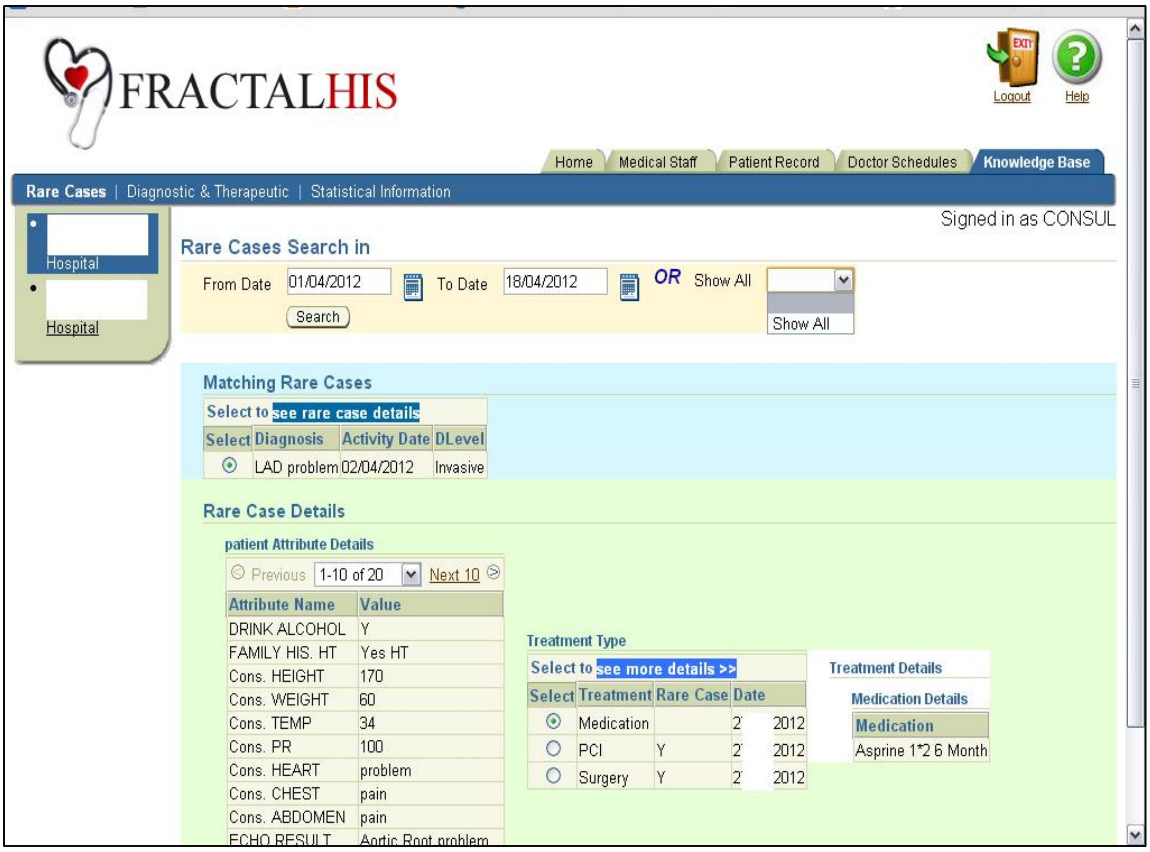


Figure 6.14: Knowledge Base Module of Rare Cases Search

In Figure 6.14, a physician can search for patient treatments for rare cases within the hospital by inserting details for the search criteria, such as providing the inclusive dates of the treatment or selecting “show all”. After the *Search* button is clicked, the results are shown under this button. Physicians can see all details related to each rare case by navigating through patient attributes, treatment types, and treatment details, including the final results of the treatment. On the same page, the physician can directly see all rare case details of other hospitals by clicking on the hospital name on the left side and conducting the aforementioned search procedure.

On the same page of the knowledge base module, physicians can see all the diagnostic and therapeutic treatments carried out by physicians within the same hospital and between different ones. This step can be done by clicking on the Diagnostic & Therapeutic subtab in the previous page. The details of the page under this subtab are shown in Figure 6.15.

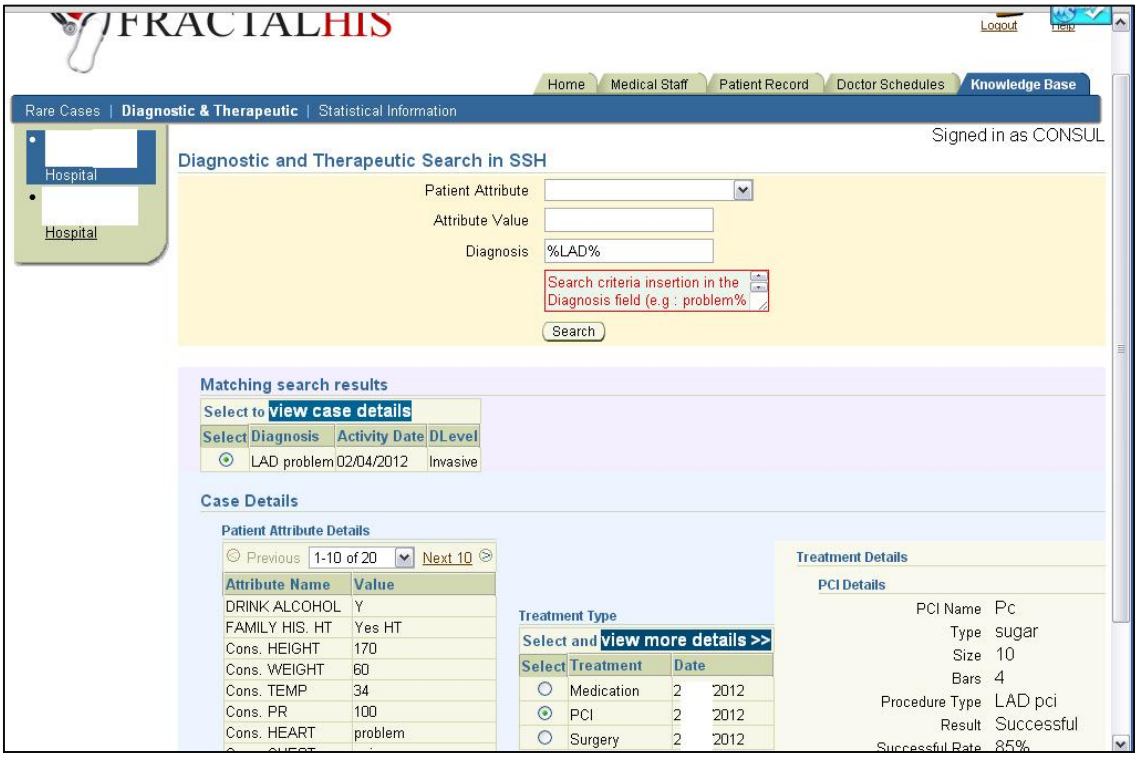


Figure 6.15: Knowledge Base Module of the Diagnostic and Therapeutic Search

In Figure 6.15, the physician can navigate the aforementioned subtab to see the diagnostic and therapeutic treatments performed by physicians from different hospitals. First, at least one of the boxes should be filled out by the physician to perform the information search; if the physician does not fill out all boxes, the system displays information on all successful diagnostic and therapeutic treatments in the hospital. The search criteria of this page include patient attribute as well as attribute value and/or diagnosis. The physician can also directly see all diagnostic and therapeutic treatments in other hospitals by clicking on the hospital name on the left side and conducting the aforementioned search procedure.

Finally, the same page of the knowledge base module for physicians shows the statistical information of different hospitals as diagrams (see Figure 6.16).

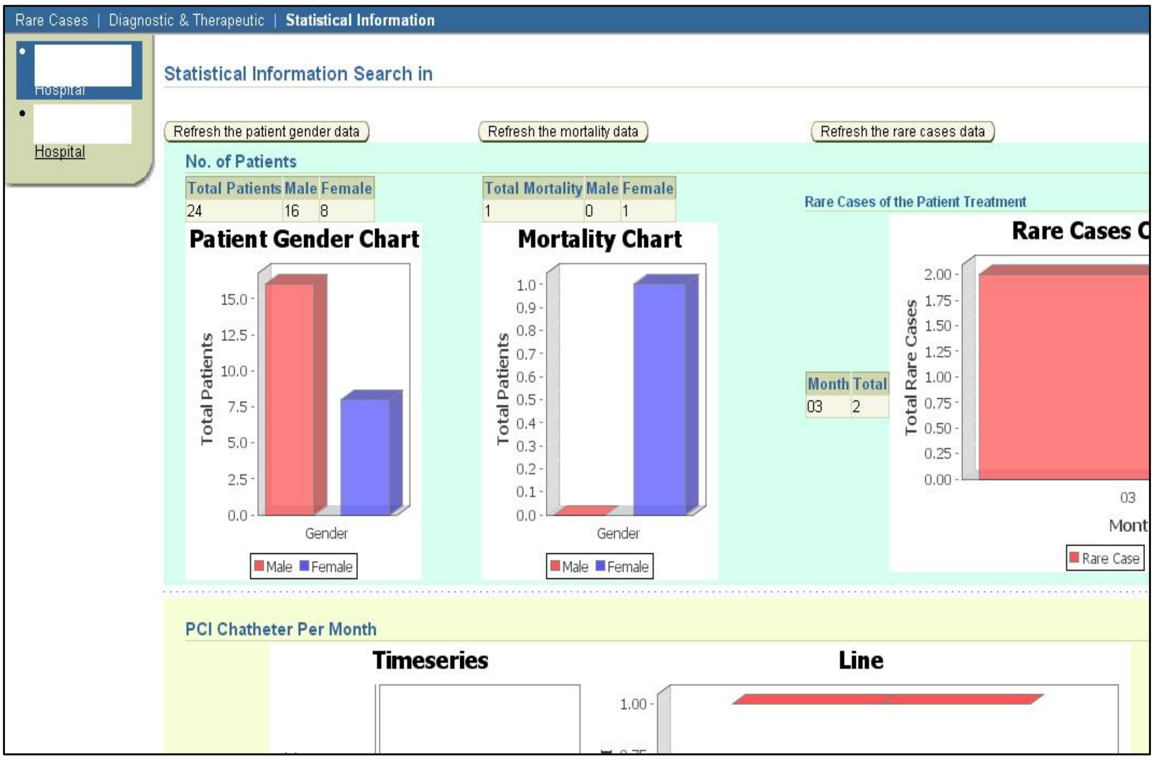


Figure 6.16: Knowledge Base Module of the Statistical Information

In Figure 6.16, physicians can view statistical information such as the number of patients, mortality rate, number of rare cases, percutaneous coronary intervention (PCI) operations per month, and surgeries per month by clicking on the Statistical Information subtab found in the page of the knowledge base module. Each type of statistical information has a *refresh* button to allow users to obtain updated information in real time.

Reference Module

The reference module is available only for users with administrator roles. Clicking the tab for this module displays the reference page (see Appendix G). The user can add or update the data on all subtabs of this page, which will be used as bases for other modules.

Help Module

The help module includes a single page available to all users and contains documentation about all aspects of the system modules. This page appears in a separate window when the user clicks the *Help* button on any page (see Appendix G).

Logout Module

Once the users complete the work and the navigation, they can log out by clicking the *Logout* button. The logout module displays a confirmation message with two buttons: *Yes* and *No*. Clicking *Yes* logs the user out of the FHIS and returns the user to the public home page. Clicking *No* (or the *Cancel* button at the top of the page) returns the user to the secure home page of the hospital website (see Appendix G).

6.3 Testing of the FHIS

The FHIS was initially put through a testing procedure, and then evaluated by potential users. These potential users were the medical staff of the two selected hospitals in this study. The testing was necessary to control the quality of the system and determine whether the system can handle real applications. The primary purpose of testing was to ensure that the program and its resulting components fulfilled the requirements specification and eliminated the errors (Kit, 1995). Thus, a systematic test procedure was required to ensure that the system was tested thoroughly and completely. The FHIS system followed the classical strategy for testing software, beginning with the unit or component testing and working toward integration and system testing as a whole (Kit, 1995). Figure 6.17 shows that the testing process starts from component (unit/module) testing, followed by integration testing and finally system testing. However, the back arrows show that the reverse testing takes place as defects or errors are discovered. Programming and coding adjustments are required to rectify the errors.

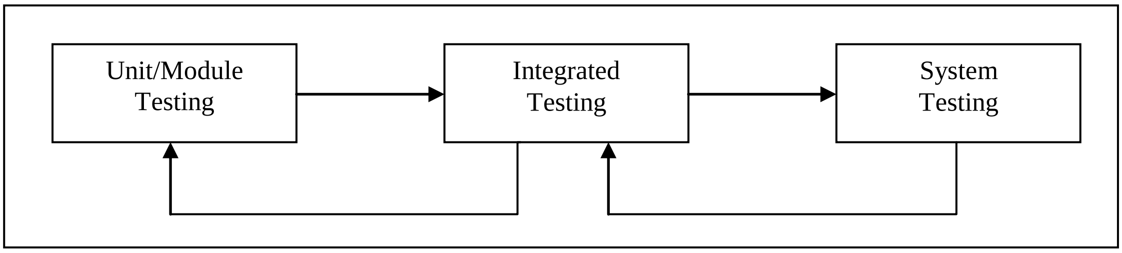


Figure 6.17: Process Flow of System Testing

The FHIS was considered as a fairly simple system consisting only of system modules and agent modules that were integrated into it. Therefore, the entire system should be tested as a single unit. The testing process will proceed in stages when testing is carried out incrementally in line with the system implementation. The following subsections explain the FHIS testing process starting from component (unit/module) testing, followed by integration testing, and finally system testing (see Figure 6.17).

6.3.1 Unit Testing

A small function conducted on the individual components of the FHIS is indicated as unit testing. All components of the FHIS modules are tested independently to ensure that they perform precisely in accordance with the documented specifications. For instance, Table 6.2 and 6.3 respectively show the unit testing for the Login Module and the Medical Staff Module.

Table 6.2: Unit Testing for Login Module

Test Case	Output	Analysis of the test
1. Insert user name and password	No error	Successful - User able to access to the home page of the hospital.
2. Incorrect user name or password	Error message	Login form is displayed again indicating that the unit is working well. Then, the error message comes out as ('Invalid Username or Password').

Table 6.3: Unit Testing for Medical Staff Module

Test Case	Output	Analysis of the test
1. Insert a new medical staff details	No error	Successful - Record saved successfully message is displayed.
2. Not all required information is inserted	Error message	Medical staff form is displayed again indicating the unit is working well. Error message is ('Form validation failures a required value must be entered'), Fields marked with * are required.
3. Edit/Update old information of any medical staff	No error	Successful - Changes saved successfully message is displayed.

6.3.2 Module Testing

The collection of dependent components of the FHIS modules is indicated as module testing. The goal of this test is to assess the interfacing and integration between the R&D agent modules and the FHIS interface modules that comprise the entire system. For example, Table 6.4 presents the module testing between the Patient Record Module and the R&D agent within the same hospital.

Table 6.4: Module Testing between the Patient Record Module and the R&D Agent

Test Case	**Output**	**Analysis of the test**
1. Insert new patient details	No error	Successful – This event triggers the R&D agent to consider a new patient insertion and add one to the number of patients in the statistical information.
2. Update the consultation status of a patient to be completed	No error	Successful – This event triggers the R&D agent to consider the completeness of the patient treatment. Then, the R&D agent directly keeps the details of the patient treatment in the KB part of the KB&DB Module as new knowledge. The user can see this information in the Knowledge Base Module.
3. Update the consultation status of a patient from "completed" to another status	No error	Successful – This event triggers the R&D agent to consider changing the consultation status of a patient from "completed" to another status. Then, the R&D agent directly deletes all details about the patient treatment that have been saved in the KB part of the KB&DB Module. The user can no longer see this information in the Knowledge Base Module.
4. Update the patient treatment status as "rare case"	No error	Successful – This event triggers the R&D agent to consider the patient treatment as a rare case. Then, the R&D agent directly keeps all the details of the patient treatment in the KB part of the KB&DB Module. The user can see this rare case as new knowledge from the Knowledge Base Module.
5. If any error occurs between the system modules and the R&D agent modules	Error message	The same module is displayed with a red error message that indicates the erroneous part between the system modules and the R&D agent modules.

6.3.3 Integration Testing

The FHIS proposed in this study involves similar units that function as subsystems called R&D agents. The connection among these agents is indicated in integration testing as a collection of modules integrated into the subsystems. Subsystems may be independently designed and implemented. Subsystem interface mismatch is often detected and rectified at this stage. For example, Table 6.5 shows the integration testing among two R&D agents within two different hospitals.

Table 6.5: Integration Testing among R&D Agents

Test Case	Output	Analysis of the test
1. A new activity occurs in one hospital	No error	Successful – This event triggers the local R&D agent of the hospital to consider this event and send an announcement of this event to the R&D agents of other hospitals to generate a view. Then, the user can see any new activities in other hospitals by navigating the Knowledge Base Module and clicking on the names of the other hospitals.
2. If a problem arises in the connection among R&D agents	Error message	When the user navigates the Knowledge Base Module and clicks on the names of the other hospitals, the page displays an error message indicating a connection problem.

6.3.4 System Testing

Upon completion of the unit, module, and integration testing, the entire system (i.e., the FHIS) is tested in the two participating hospitals to ensure that the software product runs well. System testing done include security testing and performance testing.

6.3.4.1 User Security Testing

User security testing is aimed at verifying the protection mechanism built into the FHIS to protect the FHIS from unauthorized users and hackers. In the security testing, the potentials user attempts to hack into the FHIS. The user in the FHIS is given a user name and a password created previously by the administrator of the FHIS in each hospital. The FHIS cannot be accessed without the appropriate user name and password (see Table 6.6).

6.3.4.2 Performance Testing

Performance testing is conducted to test the run-time performance of the software in the context of an integrated system. Hardware resources appear to be more important at this stage and are often necessary to measure the effectiveness of hardware utilization such as processor cycles. For a system to perform well, a higher-capacity RAM and a fast processor are essential, especially for the FHIS because such a system works as a distributed system with multi-servers.

6.3.5 User Acceptance Testing

User acceptance testing, which is typically the final phase of the system testing, ensures that the product complies with the user's requirements. A set of input data and expected results that test the FHIS with the purpose of causing failure and detecting faults is conducted as a test case. The medical staff of the two selected hospitals in this study had the opportunity to test the system from April 2012 to September 2012. The results of the test were recorded and evaluated. Some of the test cases are tabulated in Table 6.6.

The researcher initially informed the hospital managers about the testing and evaluation of the FHIS. This process was done through a written letter and personal visits. Official permissions were obtained from the hospital managers. The letters of approval are shown in Appendix E.

During the first month of the implementation of the FHIS in the two participant hospitals, the researcher provided a training course for the medical staff on how to use the FHIS on a daily basis both individually and in groups. The FHIS was implemented for six months in the real testing stage. Then, the evaluation process of the FHIS aimed at assessing the usability of the system and the improvement of cooperation among physicians with regard to sharing information and skills in patient treatment was carried out. The results of this process are detailed in the following section.

Table 6.6: Test Cases

Test Condition	Expected Result	Pass/Fail	Remarks
1. Connecting to the system	User can open the system.	Pass	Rare failures to connect the user to the system are influenced by electricity and internet service in the location.
2. User can log into the system	User logs in without any difficulty.	Pass	If the user fails, he/she is given three more tries.
3. User can view the particular interface modules	User can browse through the particular interface modules with just a mouse click.	Pass	
4. User can insert, edit, and update patient or medical staff information	User can easily key in the patient or medical staff information daily.	Pass	
5. User can find specific information about the patient or the medical staff using related search criteria	User can obtain information quickly.	Pass	The user simply needs to insert the correct information in the search criteria boxes.
6. User as the physician can find new knowledge from the Knowledge Base Module	User can acquire new knowledge by simply navigating the components of the Knowledge Base Module (e.g., Rare Cases, Diagnostic and Therapeutic, and Statistical Information).	Pass	The physician only needs to insert the correct information in the search criteria boxes.

6.4 Evaluation of the FHIS

In any system development, the evaluation process is essential to obtain feedback from the potential users to fulfil their requirements. These potential users refer to the medical staff involved in the research (see Table 3.2 in Chapter 3). In this study, the evaluation of FHIS was carried out in two selected hospitals (Hospital A and Hospital B) as case studies (see Figure 3.3 in Chapter 3). This evaluation was conducted to measure the usability of the system and the cooperation among physicians by using the questionnaire and in-depth interview instruments of data collection (see section 3.3.5 in Chapter 3). The following sections show the results of the aforementioned measurements.

6.4.1 Usability of the FHIS

The measurement of the usability of the FHIS was conducted using the System Usability Scales (SUS). The SUS consists of ten items, with the odd-numbered items worded positively and the even-numbered items worded negatively. It was developed by Brooke (1996) to measure the effectiveness, efficiency, and satisfaction of the system, as shown in appendix C.

Following the usability test, 56 of the users (i.e., physicians) were presented with a short survey based on the SUS. The SUS is a simple, ten-item scale that provides a global view of the subjective assessments of usability, which is calculated based on survey results. The SUS scores in this study (Table 6.7) followed a 100.00 scale (the higher the score is, the higher the level of satisfaction).

Table 6.7: SUS Scores by the Participants (Physicians) (N=56)

Participant	**SUS Scores**	**Participant**	**SUS Scores**	**Participant**	**SUS Scores**
Phy 01	85	Phy 20	75	Phy 39	70
Phy 02	80	Phy 21	92.5	Phy 40	72.5
Phy 03	97.5	Phy 22	75	Phy 41	65
Phy 04	90	Phy 23	82.5	Phy 42	85
Phy 05	80	Phy 24	100	Phy 43	82.5
Phy 06	75	Phy 25	77.5	Phy 44	62.5
Phy 07	47.5	Phy 26	70	Phy 45	87.5
Phy 08	87.5	Phy 27	70	Phy 46	65
Phy 09	92.5	Phy 28	65	Phy 47	67.5
Phy 10	62.5	Phy 29	62.5	Phy 48	82.5
Phy 11	82.5	Phy 30	82.5	Phy 49	65
Phy 12	72.5	Phy 31	72.5	Phy 50	70
Phy 13	80	Phy 32	77.5	Phy 51	100
Phy 14	82.5	Phy 33	67.5	Phy 52	70
Phy 15	65	Phy 34	77.5	Phy 53	70
Phy 16	57.5	Phy 35	80	Phy 54	100
Phy 17	55	Phy 36	95	Phy 55	70
Phy 18	67.5	Phy 37	67.5	Phy 56	35
Phy 19	75	Phy 38	82.5		
SUS Total Score		**75.04 Mean (Overall of the participants' SUS scores)**			

Table 6.7 shows that the minimum SUS score is 35 and the maximum score is 100. In accordance with the rule of thumb on the interpretation of the SUS scores on products (Bangor, et al., 2009), the products with SUS scores above 70 are passable. In this

study, the SUS total score of 75.04 indicates that the FHIS is generally perceived to be acceptable.

The following graph (see Figure 6.18) is based on the survey results of the user opinion on usability issues of the system. The survey questions talked the learnability and other aspects of usability of the system.

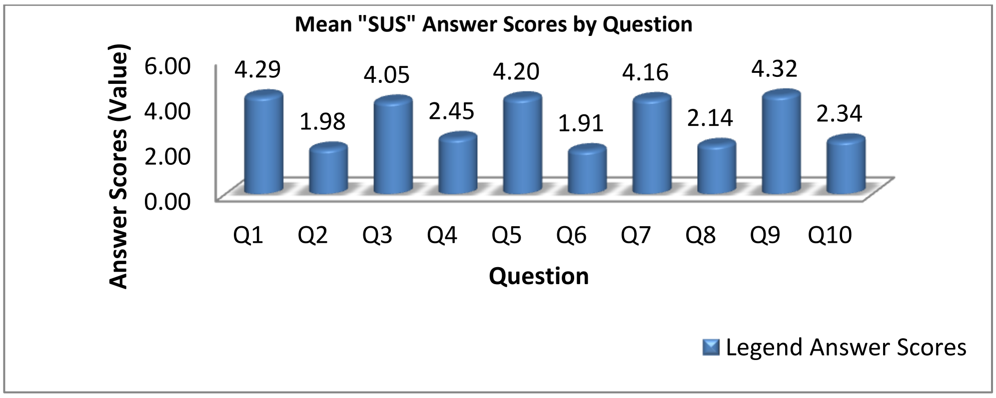


Figure 6.18: Mean Survey Results (N=56)
(*indicate that even questions are negative and that lower scores indicate higher satisfaction*)

The survey results show that the overall satisfaction of FHIS is high; the physicians find this system useful and easy to learn (Q3 and Q4), and they would like to use it in the future (Q1, a particularly high score). Furthermore, the majority of the physicians in the interviews said that the system is useful and easy to use. For example, one of them said, “Really, the system is easy in the work. I encourage all doctors to work on it” (Ev3) (see Appendix D for reference). Another said, “It is very good system and easy to use. For us, we can get many benefits from the information and knowledge of this system” (Ev1), and another one said, “For me, this system was very easy during of work. It just needs 5 minutes to learn how to use it” (Ev5). However, a number of participants suggested that they also have to explore it more before they can use it skilfully (Q10), which might be caused partly by the timed and limited nature of the usability testing. This result also indicates the necessity to improve the instructional tutorials. In addition, some of the physicians said that they need simple training to be familiar with this system.

Moreover, the issue of inconsistency should be taken into consideration (Q7), as it corresponded with many of our observations; much of the functionality are not consistent with the users' familiar way of performing these tasks and even within the system itself. The opinions of the respondents from the comment section of the questionnaire are noteworthy. Some of them reported that the system is complex and that they need more training courses to use such a system. In addition, they said that the system should be updated to include more details of patients, such as chest X-ray, images, and videos of operations, which were also mentioned by some of the physicians in the interviews. For example, one of the physicians in the interviews said "… it is important of this system to have videos and/or pictures of operations that have been done for patients beside the information about those operations. In the beginning, this system is very good for cooperation; but needs some updating in order to be more effective" (Ev2).

6.4.2 Cooperation among Physicians with the implementation of FHIS

The measurement of cooperation among physicians was conducted using the same scale that was used in Section C of the questionnaire of first stage of this research (see section 3.3.4.1 in Chapter 3). The pre-implementation and post-implementation stages were tested to measure the cooperation among the same participants. Therefore, the scale of measuring the levels of cooperation among physicians with regard to sharing information and skills in patient treatment within the same hospital and between different ones was distributed within a pre- and post implementation of the FHIS among the same sample of physicians.

Following the cooperation test, 56 of the users (i.e., physicians) from total of 100 (see Table 3.2) were presented with a survey to measure the levels of cooperation among them with regard to the sharing of information and skills in patient treatment within the selected hospital environment. This test measured the levels of cooperation among physicians during the pre- and post implementation of the FHIS. A paired samples T test using the SPSS software was carried out to compare the mean test scores before (pre-test) and after (post-test) the system implementation. This test was achieved using a Kolmogorov-Smirnov test and the data were normally distributed. This study aims to observe the improvement of the levels of cooperation among physicians within the hospital environment. The results are shown in Table 6.8; the mean score of the pre-implementation of the system for the overall level of cooperation among physicians (pre-test) was 14.34, whereas that of the post implementation of the system (post-test) was 35.32. The standard deviation for the pre-test was 4.29, and that for the post-test was 4.99. The number of participants in each test (N) was 56.

Table 6.8: Paired Samples T Test

	N	**Mean**	**Std. Deviation**	**T**	**Df**	**Sig. (2-tailed)**
Pre-test	56	14.34	4.291	-20.486	55	.000
Post-test	56	35.32	4.991			

The Sig. (2-Tailed) (p) value in the study was 0.000 (see Table 6.8). As this value is less than .05, we can conclude that a statistically significant difference exists between the mean of the levels of cooperation among physicians for the pre- and post implementation of the FHIS ($t(55) = -20.486$, $p<0.05$). The statistical values of these paired samples revealed that the mean of the levels of cooperation in the post implementation was greater than that in the pre-implementation. Thus, the levels of cooperation among physicians with regard to the sharing of information and skills in patient treatment could be enhanced significantly with the implementation of the FHIS.

Moreover, the majority of the specialty physicians in the interviews mentioned that the FHIS certainly has a significant effect on their cooperation with fellow physicians (see Appendix D). For instance, one of the physicians said, “There are many things in this system through which we can see and evaluate the work of other doctors. In addition, the sharing of information leads to an increase in cooperation among doctors in the hospital environment” (Ev10), and another said, “This system can improve the cooperation among physicians from zero to above 75% because of unavailability of the any type of cooperation among physicians within same and between different hospitals” (Ev1). In addition, the improvement of cooperation among physicians in such a system leads to the improvement of the skills of the physicians both in patient treatment and healthcare services, as mentioned by many of the participants. For example, one of the participants said, “Surely, this system will impact on our skills, especially in the patient treatment. It will effect at rates varying from a doctor to another” (Ev1), and another said, “Certainly the information available in this system affect on our experience in the patient treatment because the system publishes my work between doctors and I can see the work of other doctors. By this way, this work provides the information and knowledge so that it is for doctors to gain experience of others and this reflects a positive influence on health services provided by the centre for patients” (Ev10). With regard to the enhancement in the healthcare services, one of the physicians said, “In my opinion, this system updates and improves our knowledge which leads to improve healthcare services by providing a good care to our patients” (Ev1), and another said, “…it provides a good quality of care for patients. For instance, the system reduces the time consuming of the patient diagnosis because of the availability of the historical information for patient. Next, it reduces the harm to the patient due to the repetition of investigation processes in the old system. Finally, this system decreases the effort of medical staff during the daily work” (Ev5).

Finally, when the researcher asked about the usefulness of the FHIS implementation, the specialty physicians answered that the implementation certainly brings many benefits to the hospital environment, especially for physicians. One of the specialty physicians said, “This system has brought many things. For instance, it provides us with a good information and knowledge. Next, it brings progress to our hospital. Finally, the system is new in our country it has never seen before” (Ev6). Another one said, “This system has brought many things. First, the system brings progress to our centre and makes us to feel that we can reach our neighboring countries such as Europe countries because we are weak in the technology information. Second, it brings many benefits for our patients and doctors. For instance, in the previous years if somebody told you someone has heart disease you will think he is an old person; but current this disease available among young people (i.e. 25-30 ages). Therefore, this system can help us to follow up these cases and find why it happened as well as we can see the statistical information of these cases how they increased by months and/or years. Next, like this system reduces the load of hospital to provide services. Finally, it increases the cooperation among physicians within the hospital environment due to the absence of this type of cooperation in the previous system” (Ev5). Another interview respondent answered, “Application of the system develops the work, increases the attention of doctors with patients and becomes a diagnosis of the patient in a scientific, well and error-free as possible. This system has the registration of all services provided to the patient. In addition, it is easy to find the patient information and which physician treated this patient and how they were treated. Finally, this system provides cooperation between doctors, whether inside or outside the hospital” (Ev7). Another interviewee said, “The system is very important and beneficial regarding the science, teaching, research and information. These four points that I mentioned previously very important for each healthcare organization in order to show the functions for each healthcare centre. In addition, this system provides a good way of cooperation and sharing of information among physicians in order to enhance the outcomes of the centre" (Ev8).

In conclusion, based on the previous results, the implementation of the FHIS can improve the cooperation among physicians with regard to sharing information and skills in patient treatment within the same hospital and between different ones. The FHIS was found to be beneficial in terms of supporting healthcare information, research, and teaching to improve physicians' skills, which leads to the provision of good quality care for patients and to the enhancement of healthcare services within the hospital environment.

6.5 Summary

This chapter presents a detailed description of the FHIS design, testing, and evaluation. In the FHIS design stage, the details of the design and implementation steps for every unit and module in the FHIS are described, and screenshots from the FHIS modules and user's interfaces are provided. In the FHIS testing, the FHIS was tested through a stringent procedure before it was released to the end-users. The system was put through unit, module, integration, and system testing as a whole. Once the FHIS was ready, it was implemented among selected hospitals in this study as case studies and was evaluated by their physicians. Questionnaires and semi-structured interview instruments were used to evaluate the system usability and the improvement of cooperation among physicians post system implementation. Questionnaires were administered to 56 physicians who volunteered to participate in this study. Semi-structured interviews were conducted with 10 specialty physicians. Then, the data gathered from the questionnaires and semi-structured interviews were analyzed; the evaluation findings show that generally, the respondents were able to use the FHIS with minimal difficulty. Moreover, the respondents were able to use the modules efficiently, and the user interface design was appropriate and functional for them to fulfill their requirements. However, some obstacles in the system implementation included poor electricity and internet services in the location. The FHIS was also found to require certain improvements, particularly an integrated patient information based on physicians' requirements. The respondents found the system to be extremely useful, especially in the facilitation of cooperation among physicians with regard to sharing information and skills in patient treatment. Such feature allows the physicians to improve their skills and enhance healthcare services within the hospital environment. From the perspective of physicians, a significant part of the FHIS was the Knowledge Base Module, as it allowed them to access up-to-date healthcare information within the same hospital and between different ones. More details on the discussion, the contributions, and the recommendations of this study are presented in the next chapter.

CHAPTER 7

SUMMARY, CONTRIBUTION, AND FUTURE RESEARCH

7.1 Introduction

This chapter presents the interpretation and summary of the research design and important research findings in relation to the objectives, which were based on previous literature and data analysis results. Key findings from the previous chapter are discussed. The recommendations derived from the findings are proposed to improve the Fractal-based Healthcare Information System (FHIS) model. The model was developed to improve cooperation among physicians in sharing information and their skills in the patient treatment within different hospitals in the country. The significance and contributions of this study is discussed next. Some suggestions are also made as possible extensions of this study for future research. Finally, conclusions are made to wrap up the study.

7.2 Summary of the Study

This section presents a brief overview of the study. The summary recaptures the statement of the problem, provides a short description of how the study was conducted, and reports the major findings in relation to the research objectives.

7.2.1 Overview of the Study

Cooperation among physicians is lacking in many developing countries including Iraq regarding the sharing of information and skills for patient treatment through cooperative Healthcare Information Systems (HISs) within the same, and between, different hospitals to improve physician skills (Ali, et al., 2011). This lack in cooperation occurs because HISs are isolated from each other and mostly use manual systems (Ali, et al., 2011; Braa & Humberto, 2007; Chiasson, et al., 2007; Dembo, 2010). Therefore, difficulty in sharing healthcare information among physicians is prevalent within the same hospital and between different ones in real time, particularly when such information is important in supporting the physician decisions, enhancing knowledge and skills, and improving healthcare services (Dembo, 2010; Kannampallil, et al., 2011; Mun, et al., 2009). Several researchers have developed cooperative HISs models to improve cooperation among physicians in sharing healthcare information; however, these models have been developed as patient information depositories for the exchange of information among medical staff to concentrate on patient problems and provide effective care. No studies have focused on the development of a cooperative HIS model in improving physician skills. This absence of studies may be due to several reasons: managing and controlling huge amounts of data in complex healthcare systems is difficult, healthcare centres wishing to maintain autonomy, flexible cooperative approaches in developing cooperative HISs are not the norm, and real-time acquisition of new knowledge from external sources is unavailable for the formation of a multi-expert care team (Dembo, 2010; Skilton, et al., 2007; Skilton, et al., 2008). Cooperation among physicians can take the form of meetings in discussing difficult cases and designing appropriate treatment plans. However, some physicians may not be able to attend these meetings, which could be organized by the research and development (R&D) unit of the hospital to discuss cases (Medical Council of Canada, 2012), because of time constraints (Alwan, 2004; Burnham, et al., 2012; World Health Organization, 2006); thus, the opportunity to share knowledge and skills with other physicians is lost (Kuziemsky & Varpio, 2011). Most developing countries, including Iraq, have poor levels of cooperation in sharing information and patient care skills among physicians within hospitals; poor cooperation among physicians could lead to negative outcomes, including poor medical skills that yield disastrous consequences (Ali, et al., 2011; Burnham, et al., 2012).

To address the aforementioned problem, this study developed the FHIS model, which is based on the fractal theory and its features. This model was developed to improve cooperation among physicians in sharing information and skills in real time for patient treatment, improve physician skills, and enhance healthcare services within different hospitals. Thus, the study aims were to achieve the following objectives:

- Determine the current levels of cooperation among physicians with regard to sharing information and skills in the patient treatment, within selected Iraqi hospitals;
- Determine factors that affect cooperation among physicians with regard to sharing information and skills, within the hospital environment;
- Determine how the activities of R&D units affect cooperation among physicians; and
- Develop a FHIS model intended to improve cooperation among physicians with regard to the sharing of information and skills.

This study employed a mixed methods approach that combines quantitative (positivist paradigm) and qualitative (interpretive paradigm) methods for data collection. This approach was chosen because the systematic synthesis of different methods will compensate for some of the inherent weaknesses of individual methods, and the strengths and weaknesses of quantitative and qualitative methods can complement each other to achieve the desired outcomes, specifically in healthcare services research (Bryman, 2008; Creswell, et al., 2011; Curry, et al., 2009; Kopala & Suzuki, 1999). Data collection was performed only on two government hospitals (Hospital A and Hospital B) in the Kurdistan region of Iraq because of the limitations mentioned in

Chapter 1. Questionnaires and semi-structured in-depth interviews were employed to collect data for this study in two stages.

In the first stage, both instruments were employed to collect empirical data to achieve the previously mentioned objectives of the study. The questionnaires (Appendix A) were distributed to 100 physicians to collect quantitative data; however, only 81 questionnaires were completed and considered for analysis. To complement these data and obtain an in-depth understanding of the information collected, a subsample of 10 specialty physicians among the participating physicians were selected for semi-structured in-depth interviews (Appendix B). The complementary method of the quantitative and qualitative sequence model was also conducted during the data collection process (Morgan, 1998).

In the second stage, questionnaires and semi-structured interviews were employed to evaluate the implementation of FHIS by physicians in participating hospitals. Physician FHIS implementation is important to achieve the main objective of this study, which is related to the development of an integrated cooperative HISs to improve cooperation among physicians. This cooperation considered regarding to the sharing of information and physicians' skills in the patient treatment within different hospitals to improve the physicians' skills. Cooperation of among physicians will lead to the provision of quality care for patients and the enhancement of healthcare services within the hospital environment. The previously mentioned instruments were combined in a complementary fashion and were used to measure the usability and effects of the system in improving cooperation among physicians. Questionnaires (Appendix C) were distributed to 56 physicians who volunteered to participate in this research study. The questionnaires were divided into three sections. The first section employed the system usability scale (SUS) (Brooke, 1996) to evaluate the usability of FHIS in measuring the system effectiveness, system efficiency, and user satisfaction. The second section evaluated the extent to which FHIS improves cooperation among physicians in sharing information and skills for patient treatment within the hospital environment. The second section was distributed twice to the same physicians during the pre-implementation and post-implementation of the FHIS. The third section was used to provide comments on the usefulness and relevance of the FHIS regarding the cooperation among physicians. To obtain an in-depth understanding of the FHIS evaluation, a semi-structured interview instrument was used with ten specialty physicians. The details of the findings in the relation to the research objectives of this study are outlined in the following section.

7.2.2 Strengths and Weaknesses of the FHIS System

7.2.2.1 Strengths of the proposed FHIS system

The FHIS efficiently provides valuable information for physicians, a flexible system structure, and great autonomy for its units. In addition, the FHIS is a decentralized system, as it is built on the fractal concept (see Section 2.5.1 in Chapter 2).

The efficiency of the FHIS lies in its support of physicians by providing them with productive information through shared information and skills in patient treatment (see Section 6.4.2 in Chapter 6). Through the FHIS, physicians can acquire knowledge from others in real time and at any time because the system is developed based on agent-based techniques (see Section 6.2.1.3 in Chapter 6). Many cooperative HISs have been proposed by several researchers (see Section 2.4 in Chapter 2). However, most of these researchers focused on the sharing of patient information among medical staff to provide improved services to patients. Literature review done has not identified any similar study attempted to develop a cooperative system that would aid in the improvement of the skills of physicians for timely patient treatment. Hence, no comparative between similar systems can be done.

The FHIS has a more flexible structure than other distributed systems. This superiority can be attributed to the fact that the FHIS is based on fractal theory and its features (see Section 2.5.1 in Chapter 2). One of the fractal features is self-similarity. This feature refers to all units in the FHIS having the same structures and goals. The existence of this feature in the FHIS provides great flexibility in system structure (see Figure 6.3 in Chapter 6). That is, the FHIS units can easily be added, updated, and removed without affecting other units in the system.

Moreover, the units in the FHIS have higher autonomy compared with units in other distributed systems because such units of the FHIS possess the self-organization of fractal features (see Section 2.5.1 in Chapter 2). This feature refers to the freedom of units in the FHIS and its implementation functions. The self-organization feature indicates that each unit in the FHIS has sufficient freedom to execute activities in the system (see Figure 6.3 in Chapter 6).

In sum, the FHIS has greater efficiency in providing productive information for physicians compared with the cooperative HISs mentioned in the literature review of this study. In addition, the units in the FHIS have higher autonomy and more flexibility compared with units in other distributed systems.

7.2.2.2 limitation in the evaluation of the proposed FHIS system

In evaluating the proposed FHIS system, a comparative analysis with other system entities or organizations with similar systems cannot be carried out. This limitation is expected because the FHIS is a new concept of a cooperative system for organizations, particularly for a hospital environment, as mentioned in the literature review (see Chapter 2). Similar systems have not been implemented before. Nevertheless, a comparative analysis was carried out in this study based on the pre-implementation and post-implementation of the proposed FHIS in the two hospitals (Hospitals A and B) selected for this research.

The comparative analysis of the FHIS was conducted by using questionnaires and semi-structured interviews to validate system usability and the extent to which the system improves the cooperation among physicians in terms of information sharing and their skills in patient treatment (see Section 6.4 in Chapter 6). The system usability results indicate that the FHIS is generally perceived by physicians to be acceptable (see Section 6.4.1 in Chapter 6). In addition, the cooperation among physicians in sharing information and skills within the same and between different hospitals shows significant improvement with the implementation of the FHIS. The majority of the physicians who participated in the study reported that the FHIS is effective in providing patient information and valuable in improving their skills in patient treatment through knowledge and skill sharing. The same physicians also suggested that the FHIS is a key factor in facilitating the cooperation among physicians in terms of the sharing of information and skills within the same and between different hospitals. These results are discussed in detail in Chapter 6 (see Section 6.4.2).

In conclusion, the FHIS has many benefits based on the viewpoint of physicians. In particular, the FHIS system can provide productive information, facilitate knowledge and skills sharing among physicians, and promote cooperation among physicians in the sharing of information and skills within the same and between different hospitals.

7.2.3 Discussion of the Findings in Relation to the Objectives

(i) Determine the current levels of cooperation among physicians with regard to sharing information and skills in the patient treatment, within selected Iraqi hospitals

This section provides the findings related to the first research objective, which in turn answers the first research question. Findings on the basis of literature reviews, survey analyses, and in-depth interviews show that a lack of cooperation among physicians exists in sharing information and skills in hospitals.

Studies (Ali, et al., 2011; Gaboury, et al., 2009; Hameed, et al., 2008; Kumar, et al., 2012; Mengiste, 2010; Scandurra, et al., 2008; VanVactor, 2011; Yang, Liu, et al., 2010) indicated that weak cooperation is prevalent among medical staff in many developing countries particularly in sharing healthcare information through computerized systems.

The findings in Section C of the questionnaire (Appendix A) indicated that little to no cooperation is present among physicians with regard to the nine types of cooperation (average mean = 1.994) within the selected Iraqi hospitals. From the questionnaire, 56.8% of the respondents (n=81) indicated that little to no cooperation exists among physicians in sharing skills within the same hospital, whereas 86.4% said that little to no cooperation exists in the sharing of physicians' skills within different hospitals. Some participants likewise stated that some to good cooperation occurs regarding the previously mentioned issue. This diversity in the responses was because only one of the two hospitals had regular meetings among physicians to discuss difficult cases organized by the R&D unit. Furthermore, 86.4% of physicians (n=81) reported little to no cooperation in sharing skills via a database for information distribution in the hospital. This rating indicated that the hospital used an almost manual system for daily work. However, the rest of the physicians said that some to good cooperation exists among physicians in sharing information via a computerized system because one of the two participating hospitals used a simple computerized system for maintaining patient records. For the other types of cooperation, the majority of respondents indicated that little to no cooperation exists among physicians (see section 5.3 in Chapter 5).

Concepts on the levels of cooperation among physicians with regard to the sharing of information and skills in patient treatment are lacking, as indicated by the statements of the majority of interviewees (Appendix B). For instance, one of the interviewees said, "...there is no cooperation but in a hospital it is good but without any connection techniques just personally" (BPY4). More details are outlined in Chapter 5. The lack of cooperation among physicians is due to many factors, which will be discussed in detail in the following section.

(ii) Determine factors that affect cooperation among physicians with regard to sharing information and skills, within the hospital environment

On the basis of the literature review, survey analyses, and in-depth interviews, several significant factors were found to affect the cooperation among physicians in sharing information and skills for patient treatment within the hospital environment. The following paragraphs provide the investigation on the second research objective and the results of this investigation, which answers the second research question.

Various studies (Gaboury, et al., 2009; Mäenpää, et al., 2009; Reddy, et al., 2011; Yang, Liu, et al., 2010; Yang, Sun, et al., 2009) have found that HISs can be an important factor in improving cooperation among physicians in sharing healthcare information in hospitals. However, many developing countries including Iraq still use manual and stand-alone systems in hospitals (Ali, et al., 2011; Kumar, et al., 2012). Most HISs are isolated from each other and are mostly designed for a specific medical care unit in a hospital. Likewise, HISs do not meet user requirements for the design of such systems. This finding indicates that manual and individual systems lead to insufficient cooperation among medical staff (H. Yang, et al., 2010). Furthermore, studies (Kumar, et al., 2012; Skilton, et al., 2007; Skilton, et al., 2008; Yang, Liu, et al., 2010) have found other significant factors related to the development of integrated cooperative HISs in improving cooperation among physicians, such as autonomy of each unit in their operations in the cooperative HISs environment, and rarity of flexible cooperative approaches in sharing information as evidenced by numerous models developed as a centralized database for sharing patient information among units.

The survey analysis, particularly Section B of the questionnaire (Appendix A), indicated the background information related to HIS in hospitals. Some items in this section involved certain factors that influence cooperation among physicians in sharing information from the opinion of respondents. The analysis showed that 74.10% of the physicians (n=81) stated that they had no computer-based HISs and 88.90% said that no distributed HIS has been implemented between their hospital and other hospitals. Almost the entire healthcare system in the hospital is based on a manual system. Moreover, 97.50% of the physicians (n=81) stated that no unit in the hospital helped improve patients' process activities and that a reliable R&D unit was non-existent. In open-ended questions in the suggestions section of the questionnaire, the physicians answered that each physician works independently, and that no electronic HISs through which their activities are saved, monitored, and distributed are implemented in their hospitals. The majority of physicians also said that they do not have time to organize their work and share their skills with others. Healthcare organization systems in Iraq, particularly in the Kurdistan region, allows specialized doctors to work simultaneously in government hospitals and private clinics (Heshmati & Darwesh, 2007). Therefore, each physician has his/her own private clinic where he/she goes after working in a hospital. In addition, most physicians reported weak R&D activities in their hospitals. Some problems in sharing information and physician skills in patient treatment among physicians have been identified and shown in Chapter 5.

From the in-depth interviews, the majority of specialty physicians in the interview mentioned several significant factors that affect cooperation among physicians, such as the absence of electronic HIS in hospitals, paper-based documentation, weak R&D activities within the hospital environment, and physician independence because of time factor. Therefore, the use of manual healthcare systems in most Iraqi hospitals makes information stored on paper difficult to manage, control, and share. Moreover, physicians have no time to view patients' medical histories and share their experiences with others, thus leading to a lack of cooperation in sharing information and limited physicians' skills for inpatient treatment. The aforementioned mentioned factors extracted from in-depth interviews are shown in detail in Chapter 5.

On the basis of previous analyses of important findings, several significant factors were found to affect the cooperation among physicians in sharing information and skills for patient treatment in hospitals, specifically Iraqi hospitals. First, the use of manual and centralized systems in hospitals leads to difficulties in managing and controlling huge amounts of data; this in turn leads to difficulties in sharing data among medical staff. Second, the aforementioned factors cause difficulties for physicians in acquiring new knowledge from others in real time. Third, each unit in the development of cooperative HIS models need to have autonomy in their activities. Fourth, a flexible cooperative approach is not the norm in the development of a cooperative HISs environment. Fifth, physicians work individually in patient treatment within the hospital environment because of the time factor. Finally, the unavailability of R&D units in Iraqi hospitals lead to weak R&D activities, which could otherwise improve cooperation among staff

(Chiesa, 1996). The effects of the activities of R&D units on cooperation among physicians are detailed in the following subsection.

(iii) Determine how the activities of R&D units affect cooperation among physicians

The survey analyses and in-depth interviews suggested that a positive correlation exists between the cooperation among physicians regarding the sharing of information and the activities of R&D units. This section addresses the third research objective and answers the third research question.

Section D of the questionnaire revealed that the role of R&D unit activities is crucial in improving the cooperation among physicians with regard to the nine activities of the R&D units (mean = 1.994) in the two Iraqi hospitals. The analysis showed that 92.6% of respondents (n=81) agreed and strongly agreed that the significant role of the R&D units in hospitals is the improvement of cooperation among physicians in sharing skills. Of the total number, 92.6% also agreed and strongly agreed that this unit can enhance healthcare services in the hospital environment. Furthermore, a simple regression analysis was conducted to identify the best predictors of the dependent variable and show the proportion of variance in the dependent variable (cooperation among physicians) as explained by R&D unit activities. The results indicated that 75.2% of the variance in cooperation among physicians in sharing information and skills for patient treatment was explained by R&D unit activities. Thus, a positive correlation existed between the cooperation among physicians and the activities of R&D units. Further details are discussed in Chapter 5.

The majority of specialized physicians interviewed emphasized that the role of the R&D unit is to facilitate communication among physicians regarding patient information and treatment skills, update the knowledge of physicians, and provide the best treatment for patients. The following section outlines the development of the FHIS model.

(iv) Develop an (FHIS) model intended to improve cooperation among physicians with regard to the sharing of information and skills in real-time

The conceptual framework of integrated cooperative HISs based on the fractal approach was proposed after studying several cooperative HISs models and existing fractal-based information systems. The fractal theory and its features were adopted in the conceptual framework to develop a flexible and cooperative model, that is, the FHIS. The findings from the survey analyses and in-depth interviews were further used as user requirements in the construction of the FHIS model. This model is mainly intended to provide a concrete platform for physician–physician cooperation in sharing information and skills in real time for patient treatment. This section primarily achieves the fourth research objective and answers the fourth and fifth research questions.

The fractal theory and its features were adopted in developing the FHIS model, given that healthcare systems in many countries generally have distributed structures and consist of individual centres supported by autonomous HISs, such as hospitals. Fractal features, such as self-similarity, self-organization, dynamics and vitality, navigation, and goal-orientation, were used to link the FHIS units. First, self-similarity was adopted to represent that the structure and goal of the FHIS units are the same to increase structural flexibility and functionality among system units. Second, self-organization was employed to provide each unit in the system (i.e., hospital) full autonomy in the management of patient and hospital activities. Third, dynamics and vitality was used to monitor and propagate new activities among the FHIS units. Fourth, the navigation feature led to the attainment of better information and more efficient monitoring of progress in obtaining integrated information from different system units. Finally, goal-orientation was adopted to enhance the decision making and knowledge acquisition of physicians.

Based on the literature and the findings of this study, the FHIS model was developed by using agent-based techniques to represent each unit in the FHIS as an agent. The role of R&D unit activities in the hospital environment indicated the crucial importance of improving the cooperation among physicians regarding sharing of skills for patient treatment. Furthermore, R&D units can manage and control hospital activities, particularly the physician activities in terms of patient treatment, thus improving healthcare services within the hospital environment. FHIS agents were represented as R&D agents to manage and control physician activities and plan the dissemination of such activities among physicians within the same hospital and across different ones in real time. Moreover, the findings of this study indicated that the lack of cooperation among physicians in participating hospitals is caused by the use of manual healthcare systems, which makes information stored on paper inadequate and difficult to manage, control, and share. Based on the physicians' requirements, the information disseminated among hospitals includes physician activities in patient treatment, such as patient details, examinations, diagnoses, treatments, statistical information, and physician schedules. These requirements are discussed in detail in Chapter 5. Hence, patient information and physician activities can be stored in the FHIS. The FHIS system was developed based on web applications for real-time navigations from any location. One important aspect of the FHIS is its real-time control and storage of new activities as knowledge within the hospital environment by R&D agent modules. The FHIS shares knowledge of other physicians' skills for patient treatment among physicians by using FHIS interface modules to acquire new knowledge and improve the physicians' skills. The FHIS was developed not only to improve cooperation among physicians but also to enhance physician skills in patient treatment, thus leading to the provision high-quality patient care and healthcare services. The development of the FHIS is discussed in detail in Chapter 6.

Case study on the implementation of FHIS

The FHIS was successfully implemented for six months (April 2012 to September 2012) in participating hospitals (Hospital A and Hospital B) in this study as a real application. During this time, the evaluation of FHIS was conducted to evaluate its usability for physicians and the extent to which the system improves the level of cooperation among physicians with regard to sharing information and skills for patient treatment. This evaluation was conducted by using questionnaires and in-depth interviews. Important findings are presented in the following paragraphs.

System usability, effectiveness, efficiency, and satisfaction from the viewpoint of physicians were obtained based on survey analyses and in-depth interviews. The survey analyses showed that the FHIS obtained a high overall satisfaction rating; that is, physicians find the FHIS useful and easy to learn for future use. However, a number of participants expressed the view that the system has to be explored more before it can be used skilfully; this response might be caused by the timed and limited nature of the usability testing. In addition, some physicians stated that they need to undergo simple training to be familiarized with the system. In this study, the SUS total score of 75.04 indicated that the FHIS is generally perceived as acceptable. The SUS scores are shown in Chapter 6 in a 100.00 scale, which indicates the higher level of effectiveness, efficiency, and satisfaction in the use of the system.

An evaluation of the FHIS regarding the improvement of cooperation among physicians was conducted on the basis of the survey analyses and in-depth interviews. The scale used in the survey analysis was the same as that used in the first phase of this study. The pre- and post-implementation of the FHIS were tested to measure the cooperation among the same physicians. A paired sample t test was conducted with SPSS software to compare the mean test scores before and after system implementation. Based on the statistical values of these paired samples, the mean of the levels of cooperation in the post-implementation is greater than that in the pre-implementation. Thus, the levels of cooperation among physicians with regard to the sharing of information and skills in patient treatment improved significantly with the implementation of the FHIS. Moreover, the majority of specialty physicians in the interview mentioned that the FHIS has a significant effect on their cooperation with fellow physicians. The implementation of the FHIS was found to be beneficial in terms of supporting healthcare information, research, and teaching for improving physician skills, thus leading to the provision of good quality care and healthcare services for patients.

Moreover, the issue of inconsistency should be taken into consideration with the implementation of the FHIS. The opinions of physicians from the comment section of the questionnaires were beneficial for further system improvement. Some physicians reported that the system is complex and that they need more training courses to use such a system. In addition, some of physicians said that the system should be updated to include more patient details, such as chest X-ray images and videos of operations, to obtain more integrated knowledge.

7.3 Contributions to the Knowledge

The major contribution of this study can be assessed in two perspectives, namely, theoretical and practical. The following sub-section further elaborates each contribution.

7.3.1 Theoretical Contribution

Numerous cooperative HISs models have been proposed to improve cooperation among physicians regarding the sharing of healthcare information. However, cooperative HISs models have focused on the sharing of patient information among physicians as a centralized system to focus on a patient’s problem and provide effective care. Moreover, no cooperative HISs model has been developed to improve physician skills for patient treatment through the sharing of experiences with physicians as a decision-support system.

In this study, the main contribution was using the fractal theory and its features for first time to propose a flexible cooperative HIS model (i.e., Fractal-based Healthcare Information System (FHIS) model). The main goal of such a model was to improve cooperation among physicians in sharing information and skills in patient treatment within different hospitals to enhance physicians’ skills and healthcare services. The FHIS model was mainly developed by referring to the fractal system proposed by Warnecke (1993), which is based on the fractal theory and its features as a method of linking system units. Each unit (i.e., hospital) in the FHIS involves modules that were extracted by referring to the modules of fractal units. In addition, findings from the survey analyses and specialty physician interviews regarding physician requirements in sharing healthcare information were applied in the development of the FHIS to improve physician skills.

The FHIS model consists of decentralized and autonomous process units that retrieve and update data to provide necessary knowledge and information. This model would have tremendous benefits based on fractal features, such as self-similarity, self-organization, dynamics and vitality, navigation, and goal-orientation. This model has a flexible structure because it involves multi-units with the same structures and goals, thus providing a flexible cooperative approach in the connection of these units (self-similarity). The FHIS model also has decentralized units that provide full autonomy to each unit in their activities. Hence, each unit can easily manage and control local data and decrease global control (self-organization). In the FHIS model, units can easily be added, updated, and removed without affecting other units in the system. Moreover, each unit can manage and control hospital activities in real time, especially physician activities for patient treatment. The FHIS units can plan the propagation of a new activity as knowledge among system units (dynamics and vitality). Each unit can navigate activities within the same units and even among different ones to acquire new knowledge in real time at any time. Furthermore, physicians can use the FHIS as an information system to support their decision in patient treatment based on other physicians' experiences. The FHIS enables physicians to work individually in patient treatment and cooperatively with others in sharing skills for patient treatment within the same hospital or between different hospitals.

The current study is the first to develop a cooperative HISs model that aims to improve the cooperation among physicians to enhance their skills. The development of the FHIS model, which has been validated by empirical findings, is a significant contribution not only to the improvement of cooperation among physicians for improving skills but also to the enhancement of healthcare services within the hospital environment as a whole. No extant study has use a fractal approach in the development of cooperative HISs model. Hence, the FHIS model could be a novel model in providing an open, autonomic, flexible, and cooperative HISs environment.

In summary the theoretical contributions indicated following:

a) This study initiative is to develop a cooperative HISs model that improves the cooperation among physicians in enhancing their skills (see Chapter 6).
b) The FHIS model proposed based on the fractal theory features:
    - Self-similarity (see section 2.5.2.1 in Chapter 2): A flexible cooperative HIS model because it involves multi-units with same structures and goals.

- Self-organization (see section 2.5.2.2 in Chapter 2): Decentralized units that provide full autonomy to each unit in their activities. Hence, each unit can easily manage and control local data and decrease global control.
- Dynamics and Vitality (see section 2.5.2.3 in Chapter 2): Units can easily be added, updated, and removed without affecting other units in the system. In addition, each unit can also manage and control hospital activities in real time.
- Goal-orientation (see section 2.5.2.5 in Chapter 2): Units can plan the propagation of a new activity as knowledge among system units.
- Navigation (see section 2.5.2.4 in Chapter 2): Each unit can navigate activities within the same units and even among different ones to acquire new knowledge in real time at any time.

7.3.2 Practical Contribution

The development of a prototype FHIS is a significant contribution in this study. The poor skills and experiences of local surgeons and cardiologists in Iraqi hospitals, particularly in the Kurdistan region, could be compensated and improved through extensive and frequent use of the FHIS. Aside from providing patient information for physicians within the same hospital, the FHIS is able to provide and share productive information to different hospitals in real time. This information includes physician activities, such as rare cases of patient treatment, diagnosis and therapy of patient illness, physician schedule, statistical information related to patient gender and mortality, and the number of operations, which are all based on physician requirements in sharing information. By using the Knowledge Base Module of the FHIS interface (see Figure 6.14, 6.15 and 6.16 in Chapter 6), physicians can view all previous productive information within the same hospital and among different hospitals. Physicians will be able to know the new activities of fellow physicians in different hospitals in real time. The sharing of previous information can support physicians in acquiring new knowledge and skills from others and can provide favourable cooperation among physicians through the exchange of knowledge and evidence-based research. The propagation of productive information within the same hospital and between different hospitals in the FHIS is the role of R&D agents, which adds another dimension to the contribution of this study. R&D agents manage and control physician activities for patient treatments within the hospital and disseminate such activities among other agents in real time as knowledge. Thus, R&D activities can be improved to promote cooperation among physicians within the hospital and enhance healthcare services, such as research work among physicians. The promotion of favourable cooperation among physicians in sharing healthcare information through FHIS was customized to suit Iraqi hospitals and cardiac centres in particular. The limitations of this study were outlined in Chapter 1 (see section 1.6).

In summary the practical contributions indicated following:

a) Physicians enable to work individually in patient treatment and cooperatively with others.
b) The poor skills and experiences of local surgeons and cardiologists could be compensated and improved.
c) The sharing of information can support physicians in acquiring new knowledge and skills from each other.
d) The propagation of productive information within the same hospital and between different hospitals is the role of R&D agents.

e) The promotion of favourable cooperation among physicians in sharing healthcare information through FHIS is customized to suit Iraqi hospitals and cardiac centres in particular.

7.4 Recommendations for Future Research

Further research on the FHIS model to improve cooperation among physicians should consider the following enhancements:

1. The FHIS model requires providing integrated healthcare information for physicians including patient information and multimedia information of patient, such as chest X-ray images, and videos and images of operations that have been proven to be exemplary and highly successful. The employment of previous process can considerably promote physician skills as real exercises on patient treatment. Thus, the FHIS model can be extended to upload more patient details in each hospital.
2. In the FHIS model, the privacy issue of viewing patient information within the same hospital should be considered by providing the privacy rules in each hospital. This process would enhance the FHIS model into becoming an integrated management system.
3. Administrative and financial issues should be considered to ensure the adequate implementation of the FHIS model between the government and private hospitals. Such issues can be considered to encompass other hospital activities, such as the benefit and cost of opening a new department, which can be useful for enhancing healthcare services within the hospital environment.
4. The role of R&D agents in the FHIS model should be broadened to provide integrated patient information among different hospitals. This integration will help physicians make appropriate decisions in diagnosing patient cases and

providing suitable treatments for patients coming from other hospitals. In this expansion, agents need to consider the privacy of viewing patient information by different physicians among different hospitals. Furthermore, these agents also need to integrate patient information from different hospitals based on the medical record number of the patient in the country.

5. The development and use of data mining techniques of warehousing data in the KB part of the KB&DB module of the R&D agent should be considered based on the diagnosis of patients by physicians. This could contribute to an effective knowledge management system for supporting physician decisions.
6. The implementation of the FHIS model among different government hospitals in the territorial and central government level should be conducted within different software platforms and data models to provide a federation of autonomous systems.

7.5 Conclusions

The Iraqi nation is concerned about the worsening condition of healthcare services in its hospitals, particularly in the cooperation among physicians in sharing healthcare information by computerized systems. The healthcare system in Iraq is still centralized and hospital-based. Furthermore, current medical skills in Iraqi hospitals are very limited. Hence, immediate and effective action should be undertaken. HISs play an important role in providing healthcare information to physicians; thus, HISs can be a significant factor in developing cooperation among physicians with regard to sharing healthcare information (Reddy, et al., 2011). The development of cooperative HIS models is needed to promote such cooperation among physicians (Yang, Liu, et al., 2010). The success of a model would however largely depend on access of physicians to appropriate, flexible, and comprehensive healthcare information based on their requirements (Skilton, et al., 2008).

Physicians have been seriously considering the establishment of cooperation among themselves for the sharing of skills in patient treatment; however, many significant factors impede such cooperation. On the basis of the literature review, survey analyses, and in-depth interviews, this study identified several factors: (1) healthcare centres wish to maintain autonomy; (2) flexible cooperative approaches are not widely used in the development of cooperative HISs environment; (3) large amounts of data are difficult to manage and control by using manual and centralized database systems; (4) new knowledge is not acquired in real-time by physicians within hospitals; (5) physicians work independently; (6) R&D unit activities are weak within hospitals. Moreover, this study found that a positive relationship exists between R&D unit activities and cooperation among physicians. The FHIS model is an adequate, open, flexible, autonomic, and cooperative system model that overcomes all of the previously mentioned factors and improves the cooperation among physicians. Consequently, the FHIS model improves physician skills in providing high-quality care for patients and enhances healthcare services within the hospital environment.

The researcher would like to assert that the successful implementation of cooperative HISs needs the concerted effort of the medical staff, based specifically on physicians' requirements. The full cooperation and support from hospital administration and physicians, continuous training in updating physician skills in patient treatment, and frequent and consistent use of FHIS in hospitals and homes can improve the cooperation among physicians in our country and help enhance physician skills and improve healthcare services.

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LIST OF PUBLICATION

Article in Academic Journals

Nawzat S. Ahmed and Norizan Mohd Yasin. (2010). Inspiring a fractal approach in distributed healthcare information systems: A review. International Journal of the Physical Sciences 5(11):1626-1640. (*ISI-Cited Publication*)

Article Under Review in Academic Journals

Nawzat S. Ahmed and Norizan Mohd Yasin. (2013). Factors Affecting Cooperation among Physicians in Sharing Information within the Hospital Environment: A Study of two Hospitals, Iraq. International Journal of Cooperative Information Systems. (*Under Review*) (*ISI-Journal*).

Nawzat S. Ahmed and Norizan Mohd Yasin. (2013). Using a Fractal-based System Model to Improve Cooperation among Physicians in Sharing Information within the Hospital Environment. Computer Supported Cooperative Work. (*Under Review*) (*ISI-Journal*)

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Nawzat S. Ahmed and Norizan Mohd Yasin. (2012). Improvement of the Cooperation Feature in Distributed Healthcare Information Systems Based on the Fractal Approach: An Empirical Study. Advanced Materials Research Vol 463-464 (2012) 861-867. (*ISI-Cited Publication*)

APPENDIX A

Dear Respondent,

The research is related to using a computerized Healthcare Information System (HIS) to exchange healthcare information among physicians to improve cooperation among them. The main purpose of this questionnaire is to determent the level of cooperation among physicians in sharing information and their skills in the patient treatment within same and between different hospitals. It also aims to determent significant factors affecting such cooperation and the role of Research and Development (R&D) unit activities in the hospital environment. The following outlines the details of questionnaire sections:

This questionnaire is divided into five sections:

Section A: Contained demographic information about the respondents.
Section B: Contained background information related to the HIS in the hospital.
Section C: About professional cooperation among physicians.
Section D: About the work of the R&D unit activities in the hospital environment.
Section E: Contained five open-ended questions.

Please answer **ALL questions** by ticking (√) the appropriate box where applicable.

All data collected will be treated with strict confidence and used only for research purposes. Names will remain anonymous. Returned survey forms will be duly destroyed upon completion of the research project.

Thank you very much for participating in this research study.

Nawzat S. Ahmed
PhD Student
Metric No: WHA080031
E-mail: nawzats@uod.ac or nawzats@siswa.um.edu.my
Faculty of Computer Science and Information Technology
University of Malaya
50603 Kuala Lumpur
Malaysia

Questionnaire to the Physicians

About the integration of real-time control and planning agent-based research and development for the fractal-based hospital information system in Iraq.

Please return your completed questionnaire to the management office in the hospital.

Section A: Demographic

1. Name: (Dr)____

   (Optional)

2. Name of hospital:____
3. City: ____________________Tel:__________________________________
4. E-mail address:_____________________ H/P No.:_______________________

   (Optional)

5. Gender (*Please tick"√"*)

   ☐ Male ☐ Female

6. Highest qualification obtained (*Please tick"√"*)

   ☐ Diploma ☐ Bachelor

   ☐ Master ☐ PhD

Section B: Background Information

Please put a tick (√) at the appropriate column.

No	Information	Yes	No
1	Do you know how to use the computer-based systems?		
2	Do you know how to use and surf in the internet?		
3	Did you take any information about healthcare services from the internet?		
4	Are there any healthcare information systems in your hospital about healthcare services?		
5	Are there any healthcare information systems between different hospitals in your town?		
6	Does the hospital in your town have a system for reducing medical errors?		
7	Is there a system that shows the level of confidence in the results of operations in your hospital?		
8	Do you think the hospitals in your town are trusted units?		
9	Is there research and development unit in every hospital in your location?		
10	Do you need more healthcare services from the hospitals in your town?		
11	Do you think it is important to create a system for research and development unit activities in the hospital?		
12	Do you need to navigate the healthcare information system of the hospitals in your town?		
13	Before dealing with another hospital, do you need to know what healthcare services are available there?		
14	Do you think a real-time response to your queries is important?		
15	Do you think a real-time response to any change in a system is important?		
16	Does the connection between hospitals increase the level of trust of healthcare services?		

Section C: Professional cooperation among physicians

How do you rate the level of cooperation among physicians with regard to each of the following?

1. No Cooperation
2. Little Cooperation
3. Some Cooperation
4. Good Cooperation
5. Very Good Cooperation

1 No Cooperation	2 Little Cooperation	3 Some Cooperation	4 Good Cooperation	5 Very Good Cooperation

Please indicate your opinion by ticking (√) one box for each type of cooperation.

No	Type of Cooperation	1	2	3	4	5
1	Physicians sharing of skills in the same hospital					
2	Physicians sharing of skills in various hospitals in your town					
3	Physicians sharing of skills by means of a database for distributing information among them in your hospital					
4	Physicians sharing of skills through research and development activities among hospitals					
5	Physicians sharing of skills from different hospitals in order to improve their skills					
6	Physicians sharing of skills with regard to connecting healthcare information systems among hospitals in order to enhance the quality of healthcare services					
7	Cooperation among physicians with regard to design system for healthcare activities among hospitals					
8	Physicians sharing of skills among different hospitals in order to increase the use of human resources					
9	cooperation among physicians with regard to distributing a new activity happens in the system among them in real-time					

Section D: In your opinion, to what extent does the work of research and development unit in the hospital increases the quality of healthcare services?

Please respond to the following statements on a five scale ranging from:

1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree

Please indicate your opinion by ticking (√) one box for each statement.

No	Statement	1	2	3	4	5
1	The research and development unit improves the cooperation among physicians' skills.					
2	The research and development services in your hospital have benefits to increase the quality of healthcare services.					

No	Statement	1	2	3	4	5
3	The research and development unit makes the hospitals in your town more trusted units.					
4	The hospitals contain decentralized and autonomous organizational units for healthcare services supporting, as a research and development units.					
5	The connection between similar autonomous units (i.e. research and development units), from different hospitals increases the quality of healthcare services.					
6	The integrated view of the research and development services system among hospitals is an efficient information system for researchers and physicians.					
7	For weak research and development activities in your hospital, many physicians refer to web resources to help them in completing their research and patient treatments.					
8	The research and development activities in the hospitals in your town depend on the paper-based system managed and controlled by the group of researchers (physicians).					
9	The research and development activity in the hospital should circulate healthcare information simply and quickly among specialists to enhance the quality of healthcare services.					

Section E: Suggestions

1. Please give some suggestions about the methods used for enhancing healthcare services in the hospitals.

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2. Please give some reasons that affect the cooperation among physicians in terms of sharing of skills in your hospital.

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3. Please give your suggestions about improving physicians’ skills in your hospital.

____
____
____

4. Please suggest some obstacles encountered in the integration of a database system for the research and development unit activities in your hospital.

5. Beside your suggestions, what types of healthcare services are given to the patients in your hospital?

Thank You for Answering this Questionnaire

APPENDIX B

In-depth Interviews of Specialist Physicians

A data display matrix for analyzing patterns of response for each of the specialist physician in each hospital is shown below.

Source: Interview
Interviewee Code: APY1
Hospital Name : Hospital A
Date and Time : 13/11/2009, 11:00 am - 1:00pm
Duration of interview: 2 hours

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
For this issue, the R&D activities are weak, and we only provide the available information about our patients to the researchers. Still we have not progressed to reach the level of the advanced centres in the world. We are interested in working on this unit as soon as possible.	The role of R&D activities is very weak in order to control on the physician's activities and sharing these activities with others.	The role of R&D activities is very weak with regard to provide information to the physicians and enhance healthcare services.
Question (2): What are the objectives of the research and development unit's activities?		
In my opinion, it improves healthcare services in the hospital, increases the performance of patient treatment by supporting information to the researchers and physicians, and brings more progressive to the hospital.	Enhancing the process of researchers and physicians in the hospitals.	The role of R&D activities improves the operation activities of physicians for treating patients in the hospital.
Question (3): What are the benefits of the research and development unit's activities?		
It improves the knowledge of researchers and physicians, and makes the hospital a trusted unit, which in turn leads to the improvement of healthcare services.	Improve the knowledge of physicians in the hospital.	The role of R&D activities improves physicians' skills.
Question (4): Can you describe the patient treatment process in your hospital?		
In our centre, most of the patients are heart attack. The process of patient treatment starts from consultation units, followed by medical treatment or non-invasive units (i.e., ECG, Echo, Exercise Test, Lab Investigations, and so on) for more investigations. Thereafter, we send our patient to medical treatment, but the information is insufficient to make a decision in most cases. For the previous reason, we send our patient to an invasive unit (i.e., Catheterization unit) to obtain more information to come up with the correct decision (i.e., 100%) to diagnose our patient's case and provide him/her a good treatment. In addition, such an invasive unit has two ways of using a diagnostic catheter (i.e., to diagnose the patient's case) and a therapeutic catheter (i.e., PCI). If the therapeutic catheter is unsuitable, then we send our patient to the Cardiac Surgery Unit, but we haven't this unit in our centre. So that, we send our patient to Surgical Specialty Hospital in Erbil city to do surgery. Further, we are planning to have this unit, and just we are started to build this unit. Again, the previous mentioned steps and units represent the	Focusing on the process of patient's treatment, there are many units work together in order to provide a good care to patients. In addition, the structure of these units has a bottom-up process, starts from Non-invasive units to Invasive unit then surgery unit.	The healthcare centre's units have same goal and autonomous for decision-making. In addition, the structure of these units has a bottom-up process, as the fractal approach.

integrated cardiac centre, and also the previous steps depend on the physicians experienced. For your information, the integrated cardiac centre is a very big healthcare centre.		
Question (5): What degree of autonomy do you have for decision-making in this hospital?		
The physician has full autonomy for making a decision on the patient's case and providing treatment. Sometimes we need consultation meeting with others to discuss some difficult cases of patients.	Focusing on the process of patients' treatment, there is full autonomy for each physician in each unit.	Each unit in the healthcare centre has full autonomy for decision-making on the patient's case, as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		
Yes, in the hospital, each unit works independently; however, they have same goals, especially in the patient treatment.	In the healthcare centre, each unit works independently; but they have same goals.	Each unit in the healthcare centre works independently; but have cooperation with others on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		
We have a database; however, it is very simple not completed just only we have the number of patients and how many of them got treatment and so on. It is meaning that we have some information about our patient in Catheterization unit saved on the computer and CDs by our technician, as reports by using Microsoft Word, but very simple and not in the requirement. Overall, We don’t have complete patient records and medical history because our system is mainly based on papers, and the management has no interest in improving services such as developing a good information system.	There is some information about patients on the computer and CDs.	Database system for a healthcare information system is incomplete.
Question (8): What are the elements of this database?		
Again, the elements of database are not completed. We have some patient information, as personal information, clinical examinations, diagnoses, lab investigations, ECG, Echo, and catheterization results; however, some of them saved on the computer in the catheterization unit.	The elements of a database system are the information of patient, such as personal information, clinical examinations, diagnoses, lab investigations, ECG, Echo, and catheterization results.	To identify the elements of a database system for the healthcare information system.
Question (9): What kind of data do you need to store in the research and development unit database?		
We need all information related to our patients and physicians. With regard to patient information, it starts from diagnoses until treatment or from admission to a hospital until discharge. For physician information, the timetable has to be put in the database system to know when and where the physicians are working to exchange patients among one another.	Patients’ information and physicians’ information.	To identify the elements of database system for research and development unit.
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		

<table>
<tr><td>In the beginning, I suggest to connect only government hospitals not with any private because of difficulty to have cooperation within different levels of hospitals. For example, connect our hospital with Surgical Specialty hospital in Erbil city because of these two hospitals are government. Our hospital has not integrated cardiac centre; however, the Surgical Specialty hospital has integrated cardiac centre Therefore, We need to transfer information of the patient treatment among those two hospitals in order to improve our work. For instance, it is good idea to disseminate the information of treatment and rare cases of the treatment among physicians within two hospitals, which is meaning that all our activities on the patient treatment. Furthermore, I want to know what are the update operations and drugs, and management of the patient in advance treatment of the world, which means transferring all activities among hospitals.</td><td>Distributed process activities of hospital on the patient treatment.</td><td>Necessity of transferring hospital's activities among hospitals to acquire new knowledge on the patients' treatment.</td></tr>
<tr><td colspan="3">Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?</td></tr>
<tr><td>Timetable of doctors, number of units and the results of treatment. Further, I want to know all new procedures and rare cases done from our and other hospitals.</td><td>All physicians’ activities on the patient treatment.</td><td>Necessity of the sharing of skills among physicians.</td></tr>
<tr><td colspan="3">Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?</td></tr>
<tr><td>I want to know all new procedures and rare cases as well as all data related to our patient. Sometimes we make a consultation meeting among us to discuss any new cases and process happens in order to improve any update that leads to increase the system of education from medical staff.</td><td>Distribute any new activities happened, especially physicians' process activities, among physicians.</td><td>Disseminate new procedures and rare cases of patient treatment among physicians.</td></tr>
<tr><td colspan="3">Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?</td></tr>
<tr><td>In order to get better knowledge that I need to improve my research and work.</td><td>To get integration information and knowledge about patients' treatment.</td><td>Necessity of navigation on the healthcare information system to get the correct information and check the progress.</td></tr>
<tr><td colspan="3">Question (14): What research and development activities would you undertake in each of the following scenarios?
-- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.</td></tr>
<tr><td>Our goal is to build the surgery unit, and this unit is still in progress. Furthermore, we need more training for our medical staff and more advance instruments to diagnose the diseases.
Also, we need to create the healthcare information system and distribute the information among staff within this hospital and others.</td><td>Focusing on the development of the distributed information system for delivering the activities to all units.</td><td>Necessity of distributing healthcare information among medical staff within same and different hospitals.</td></tr>
<tr><td colspan="3">Question (15): In what ways do you think in a system for integrating hospitals would be helpful?</td></tr>
</table>

It is by connecting healthcare information systems among hospitals to see the information of new activities, which improve the collaboration among medical staff. Furthermore, this work is very important for progression of the patient management.	The benefit of integrated healthcare information systems among hospitals is to improve cooperation among physicians.	Necessity of connection healthcare information systems among hospitals in order to improve the cooperation feature among physicians by sharing their skills.
Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?		
The service that I expect is to get information on our patients' treatment and timetable for doctors, and to have knowledge about new activities have been done in the hospital. For example, I will get information when I want to know the advance treatment and intervention procedure done for the coronary patient.	To get new information of intervention procedure has been done in the hospital.	Disseminate new procedures and rare cases of patients' treatment among physicians.
Question (17): How does a physician make use of services from the research and development unit information system in his work?		
Get information for updating the education field and providing a good Knowledge base for the researchers and doctors.	To get new knowledge.	Improve the operation activities of physicians.
Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?		
In our centre, there are many reasons. For example, there is lack of appropriate medical equipment or medical units (i.e. surgery unit), lack of well experienced medical staff (i.e. lack of cardiac surgeons), lack of a healthcare information system (i.e. poor database system).	Poor in experience staff and in the healthcare information system to save patient information and physician's activities.	Poor in experience staff and poor in the healthcare information system.
Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?		
Off-course Yes, in all medicine procedure you see sometime rare cases and difficult cases; however, unfortunately with the bad information system it takes a time to see what you did and other did and how you do to provide a good treatment to these cases.	Poor Healthcare information system to save whole information about patients.	Necessity of having integrated healthcare information system.
Question (20): How would you describe the cooperation among physicians in general?		
There is poor cooperation among doctors because each doctor works independently, and there is no system to capture and save the information of all activities in our hospital. Therefore, I haven't idea of other doctors' work.	There is no system to save physicians' activities and sharing these activities among them.	Necessity of distributing healthcare information system among physicians
Question (21): Can we improve patient and public confidence in our healthcare services?		
To update more health services to the patients by creating a database to record all information about patient and by give good and advance services medically and socially.	Creating integrated healthcare information system.	Necessity of having integrated healthcare information system.
Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?		
Try to take any new opportunities present in or outside the hospital by connecting the hospital with others to discover if there is a rare case that could be addressed, and to disseminate information that can be seen by doctors in these hospitals.	Get a new knowledge from other similar units.	Necessity of connecting similar units to get more Knowledge.
Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal		

with these threats?		
Furthermore, same above to take any new opportunities present in or outside the hospital.	Apply new knowledge that has been done in other hospitals.	Necessity of connecting similar units to get more services.
Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
In my opinion, it is better to direct the previous tasks to an agent in the computer so that information can be obtained quickly.	Agent-based system to do this mission quickly.	Flexible and quick adaptive to any required information as a fractal objective.
Question (25): What further requests do you need from research and development activities in your hospital?		
We need a good connection between our hospital and other advance centres in the world.	Develop a system to connect among similar centres.	Connect similar centres in order to transfer information among them.

Source: Interview
Interviewee Code: APY2
Hospital Name: Hospital A
Date and Time : 19/11/2009, 11:30am - 12:30pm
Duration of interview: 1 hour

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
For this issue, the activities of the R&D are weak, and at most we provide the information we have about our patients to the researchers when necessary. Our patient information only available in the Catheterization unit; even so, not in the requirement as we need. In addition, the role of R&D activities in our centre is poor, because there are no facilities for creating the R&D unit.	This is meaning that the role of R&D activities is very weak in order to control on the physician's activities and sharing these activities with others.	The role of R&D activities is very weak with regard to improved physicians' skills and enhanced healthcare services.
Question (2): What are the objectives of the research and development unit’s activities?		
In my opinion, if this unit found will improve our healthcare services in the hospital and increase the performance of patient treatment. From this unit, we also can see the results of our operations and compare with other results from other physicians.	The improvement of patient treatment by increasing healthcare services and sharing physicians' activities in the hospital.	The role of R&D unit activities improves the operation activities of physicians for treating patients by sharing these activities among physicians in the hospital.
Question (3): What are the benefits of the research and development unit’s activities?		
This unit will improve the knowledge of researchers and physicians, and turn hospitals into trusted units through the sharing of physician activities.	Improve the knowledge of researchers and physicians, and make the hospitals are trusted units.	The role of R&D unit activities improves physicians' skills.
Question (4): Can you describe the patient treatment process in your hospital?		
For patient treatment process, it starts from consultation units then send patient either to medical treatment or to non-invasive units (i.e. ECG, Echo, Exercise Test, Lab Investigations, and so on) to get more information about the patient's case. After that, we also send our patient either to medical treatment or invasive unit (i.e. Catheterization unit) to get more information in order to have a right decision to diagnose our patient's case and give him/her a good treatment. By the way, this process depends on the physicians experienced.	Focusing on the process of patient treatment, there are many units work together in order to provide a good care to patients. In addition, the structure of these units has a bottom-up process.	The healthcare centre's units have same goal and autonomous for decision-making. In addition, the structure of these units has a bottom-up process, as the fractal approach.
Question (5): What degree of autonomy do you have for decision-making in this hospital?		
We have full autonomy from other units in our operation to make a decision on the patient’s case.	The level of autonomy for each physician in each unit is full autonomy to make a decision on the patient's case.	Each unit in the healthcare centre has full autonomy for decision-making on the patient's case, as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		

Yes, in the hospital, each unit works independently and these units have same goals in the patient treatment.	Each unit works independently and has the same goals of patient treatment.	Each unit in the healthcare centre works independently; however, it works cooperatively with others on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		
Yes, we only have some information about our patient in Catheterization unit saved on the computer and CDs by our technician, but very simple and not in the requirement.	There is some information about patients on the computer and CDs.	Database system for the healthcare information systems is incomplete.
Question (8): What are the elements of this database?		
Only we have patient information, as personal information, clinical examinations, diagnoses, lab investigations, ECG, Echo, and catheterization results; however, some of them saved on the computer.	Database system elements are patient information, as personal information, patient clinical examinations, diagnoses, lab investigations, ECG, Echo, and catheterization results.	To identify the elements of a database system for a healthcare information system.
Question (9): What kind of data do you need to store in the research and development unit database?		
We need all information related to patients and physicians to be saved in this unit.	Patient information and physicians information	To identify the elements of database system for research and development unit
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		
By this way, I have all information about patient treatment to be distributed among hospitals, such as the ways of treatment and new cases have been served by our physicians.	Distributed process activities of the patient treatment in the hospital.	Necessity of transferring hospital's activities among hospitals is to acquire new knowledge of the patient treatment by physicians.
Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?		
Timetable of our medical staff, statistical information about our patients, and ways and results of treatment.	All physician's activities of the patient treatment	Necessity of the sharing of skills among physicians.
Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?		
With regard to the historical data of a patient, sometimes we make a consultation meeting between us to discuss any new cases, and the process enables us to obtain fresh knowledge from our staff.	Distribute any new activities happened, especially physicians' process activities, among physicians.	Disseminate new procedures and rare cases of patient treatment among physicians.
Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?		
Yes, I need to do that, because it will help me to get more information and knowledge for my work.	To get integrated information and knowledge about patients.	Necessity of navigation on the healthcare information system to get correct information and check

		progress
Question (14): What research and development activities would you undertake in each of the following scenarios? -- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.		
Update the surgery unit, the doctors and the medical staff. Create and distribute healthcare information system among staff in this hospital and other hospitals.	Focusing on design distributed information system for delivering the development activities to all units.	Necessity of distributing healthcare information among medical staff within same and different hospitals.
Question (15): In what ways do you think in a system for integrating hospitals would be helpful?		
By the c of healthcare information systems among hospitals is to see global information of new activities, which improve the collaboration among medical staff.	There are more benefits to integrate an information system among hospitals.	Necessity of connection healthcare information systems among hospitals is to improve the cooperation feature among physicians by the sharing of physician's skills in the patient treatment.
Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?		
In my opinion, I have to get the information of patient treatment and timetable of doctors. Furthermore, it is important to get the information about new activities have been done in the fast ways.	To get new information of intervention procedure has been done for a specific disease.	Disseminate of new procedures and rare cases of the patient treatment among physicians.
Question (17): How does a physician make use of services from the research and development unit information system in his work?		
Get information for update the education field.	To get new knowledge	Improve the operation activities of physicians
Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?		
In my experience, there are some reasons. For example, there is lacked of appropriate medical equipment or medical units, maybe lack of well experienced medical staff, lack of a healthcare information system.	There is poor in experience staff and in healthcare information systems to save patient information and physician's activities.	poor in experience staff and poor in the healthcare information systems.
Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?		
Yes, I have in many times in my work field, especially to follow up my patients with documentation. Sometimes, I couldn't find some information about my patient. So that, it needs from patient to do some investigations again.	Lack of the healthcare information system to save whole information about the patient.	Necessity of having integrated healthcare information system.

Question (20): How would you describe the cooperation among physicians in general?		
It is poor, because each doctor works independently and there is no system to save doctor's work. Most of our systems are paper-based.	There is no system to save physicians' activities and sharing among them.	Necessity of distributing healthcare information system among physicians
Question (21): Can we improve patient and public confidence in our healthcare services?		
To update more health services to the patients by creating a database to record all information about patient and distributed these information among medical staff.	Creating of the integrated healthcare information system.	Necessity of having integrated healthcare information system.
Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?		
To get experience staff from outside or to get information from other hospitals.	Get a new knowledge from other similar units	Necessity of connecting similar units to get more Knowledge
Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal with these threats?		
Update the ways of treatment and provide the patient with the possible help.	Apply new knowledge that has been done in other hospitals.	Necessity of connecting similar units to get more services
Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
To group and agent for making this mission to be done useful.	agent-based system to do any job in the fast way rather than manual.	Flexible and quick adaptive to any required information as a fractal objective.
Question (25): What further requests do you need from research and development activities in your hospital?		
Connection this unit with the supplier of medical and support the needs of information, and any updates happened as well as make conference with other centres.	Develop the connection among similar centres	Connect similar centres in order to transfer information among them

Source: Interview
Interviewee Code: APY3
Hospital Name: Hospital A
Date and Time : 22/11/2009, 12:00pm - 1:00pm
Duration of interview: 1 hour

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
We have not like this unit in our hospital; however, we care about it to have. For the previous mentioned, the activities of research and development are very weak and perhaps non-existent. Furthermore, the time factor is very important to do these activities which mean that we have not enough time.	The role of R&D activities is very weak in the hospital to improve physicians' activities.	The role of R&D activities is very weak with regard to improved physicians' activities.
Question (2): What are the objectives of the research and development unit's activities?		
For the objectives of this unit are still not clear; again because we have not like these activities in our system. Depending on my experience, I think these activities will be helpful to increase the quality of our work and making better services to our patients and our staff. In the end, the main aim of this unit is to increase healthcare services.	Provide a good care to the patients by improving physician's work with regards to developed a system for R&D activities and sharing among physicians in the hospital.	The role of R&D activities improves the operation activities of physicians for treating patients by sharing these activities among physicians in the hospital.
Question (3): What are the benefits of the research and development unit's activities?		
It could help us build our knowledge and provide good care to our patients. This will be done by developing a database system that presents a global view of information for this unit. In my opinion, it is better to connect with other units from other hospitals.	Improve the knowledge of physicians by developing a system for R&D unit and connect with other similar unit from different hospitals.	The role of R&D activities improves physicians' knowledge.
Question (4): Can you describe the patient treatment process in your hospital?		
This process begins from examination, investigation, and treatment to obtain more information to make a decision in diagnosing a patient's case; however, this process is not fixed, and it depends on the physician's experience to diagnose and treat a patient's illness.	Focusing on the process of patients' treatment, there are many units work together in order to provide a good care to patients.	The healthcare centre's units have same goal and autonomous for decision-making, as the fractal approach.
Question (5): What degree of autonomy do you have for decision-making in this hospital?		
We managed our patient separately, which means that we have full autonomy to provide a good care to our patients.	The level of autonomy for each physician in each unit is full autonomy to provide care to patients.	Each unit in healthcare centre has full autonomy for decision-making on the patient's case, as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		

Of course yes, each unit in the hospital is independent, and they have same goals in the patient treatment.	Each unit works independently and has the same goals.	Each unit in healthcare centre works independently and have same goal on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		
I haven't idea. I think there is a database but not in the requirement for lacking professional persons to work on it. In our work, we have paper forms to record our patients' information. We only have partial information about our patients in the catheterization unit recorded on the computer.	There is some information about patients on the computer only in one unit.	Database system for healthcare information system is incomplete.
Question (8): What are the elements of this database?		
Patients' information, such as personal information, examinations, all investigations, and treatment.	Database system elements are patient information, as personal information, examinations, investigations and treatment.	The elements of database system only have some patients' information.
Question (9): What kind of data do you need to store in the research and development unit database?		
I think we need all information related to our patient and our staff. For example, we need historical information, investigations, diagnosis and treatment of our patients.	Patient information and physicians information	The elements of database system for research and development unit should have patients and medical staff information.
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		
It could be helpful if we transfer the information of patient, clinical examinations, investigations and type of management (i.e. statistical information regarding doctors, staff and patients).	Distributed physician's activities on the patient treatment.	Necessity of distributing physician's activities among hospitals to acquire new knowledge on the patients' treatment.
Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?		
It is better if we transfer types of investigations and treatment among physicians in our hospital and others.	Distributing the type of investigations and treatments among physicians.	Necessity of sharing of skills among physicians.
Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?		
Based on this issue, we have a discussion meeting among doctors to discuss rare cases, and the process happens with regard to having new machines, instruments, and systems as well as with a good number of professional staff to acquire more knowledge.	Distributing information among staff with regard to any new cases and process happen.	Disseminate new processes of patient treatment among physicians.
Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?		
It is very important to get more knowledge in order to improve our work and doing researches.	To get more knowledge for improving the physician's work.	Necessity of navigation on the healthcare information system to get more knowledge.

Question (14): What research and development activities would you undertake in each of the following scenarios? -- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.		
We need to update the units and to provide good machines and drugs. Furthermore, we need to train our medical staff on the new system. We should have a good healthcare information system and distributing the information of such a system among our staff and others from other hospitals in a timely manner because the time factor is very important for this mission.	Focusing on developing healthcare information system for delivering all activities to all units in a timely manner.	Necessity of distributing healthcare information among medical staff within same and different hospitals.
Question (15): In what ways do you think in a system for integrating hospitals would be helpful?		
Surely, the connection of healthcare information systems among hospitals will be helpful to provide us with any update happens in investigations and managed the different medical cases.	Integrate healthcare information system among hospitals improves physicians' work.	Necessity of connection healthcare information systems among hospitals in order to improve the cooperation feature among physicians.
Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?		
I think it will help me to get information about a new updating of medications and ways in the patient treatment.	To get a new information of activities on the patient treatment.	To get new procedures and rare cases of patients' treatment.
Question (17): How does a physician make use of services from the research and development unit information system in his work?		
To see good results of treatment and apply what I get on my patient.	To get new knowledge.	Improve the operation activities of physicians.
Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?		
Here, there are some reasons. For example, there is poor in appropriate medical equipments or units and poor in medical supplies and information system.	Poor of healthcare information system to save patient information.	poor of healthcare information system and medical units to provide a good care to the patients.
Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?		
Yes surely, I have many cases in my work; because, there is no longer a database system in our centre to record the information of our patients, especially for follow up. Sometimes my patients lose reports of investigations that we did for him/her case. Therefore, we request from our patients to do some new investigations again.	Poor Healthcare information system to save whole information about patient.	Necessity of having integrated healthcare information system.
Question (20): How would you describe the cooperation among physicians in general?		

To somehow it is good; but it is personally, which means that the communication among physicians is personally without any type of distributed information systems.	There is poor cooperation among physicians because of there is no any system for sharing information and knowledge among physicians.	Necessity of distributing healthcare information system among physicians for improving cooperation feature.
Question (21): Can we improve patient and public confidence in our healthcare services?		
Yes surely, we can improve it by having a correct information system to manage and control a number of patients and a type of surgery and so on.	Develop a healthcare information system to manage and control on the activities of the patient treatment.	Necessity of having integrated healthcare information system.
Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?		
Improve our staff an experience is by getting knowledge from outside. This will be done by communicating our centre with others.	To get a knowledge from other similar units.	Necessity of connecting similar units to get more Knowledge.
Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal with these threats?		
To update the ways of treatment again is by connecting our centre with highly or large-volume centres.	To apply new knowledge that has been done in other hospitals.	Necessity of connecting similar units to get more services.
Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
I think it is better to have this mission to a group of agents.	Agent-based system to do any job in the fast way rather than manual.	Flexible and quick adaptive to any required information as a fractal objective.
Question (25): What further requests do you need from research and development activities in your hospital?		
My request is to have more activities, such as statistical information about a number of admissions, discharges and mortality of patients as well as the type of procedures.	To get more statistical information about physician's work in the hospital.	Requesting the statistical information on the activities of physicians.

Source: Interview
Interviewee Code: APY4
Hospital Name: Hospital A
Date and Time : 23/11/2009, 12:00pm - 1:00pm
Duration of interview: 1 hour

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
Activities of the R&D are poor in our hospital due to the health system as a whole is not well-developed as well as there are lack of expert physicians. For that reasons, the activities of R&D unit are very weak and not in the requirement.	The role of R&D activities are very weak in the hospital due to a healthcare system is not well developed.	The role of R&D activities is very weak with regard to enhance healthcare services.
Question (2): What are the objectives of the research and development unit's activities?		
Surely, the main objective of R&D unit activities is to have a real database system to improve the management of patients and to plan for more developing healthcare services.	The improvement of patient treatment can be done by having a real database system to increase healthcare services and enhanced the process of physicians in hospitals.	The role of R&D unit activities improves the operation activities of physicians for treating patients by increasing healthcare services as having a real database system.
Question (3): What are the benefits of the research and development unit's activities?		
I think the main benefit of R&D unit activities is to correct information about the burden of disease in the area and to plan for managing the patient and controlling the risk factor of the disease locally, as well as to improve primary and tertiary care. Moreover, there are many other benefits that we cannot count, such as having a global view of information in this unit by connecting with others from different hospitals. Further, It will help to increase the healthcare services and update the information available for physicians.	Provide correct information to medical staff and make the hospital is trusted unit by cooperation with other same units.	The role of R&D unit activities improves physicians' skills by connecting healthcare information systems among hospitals.
Question (4): Can you describe the patient treatment process in your hospital?		
Every unit starts to care the patient from the beginning starting of information history, diagnosis and managed independently.	Focusing on the process of patients' treatment, there are many units working independently and cooperation each other to provide a good care to patients.	The healthcare centre's units have same goal and autonomous for patient treatment, as the fractal approach.
Question (5): What degree of autonomy do you have for decision-making in this hospital?		
We have full autonomy in our work to make a decision on the patient's case because of each hospital has the autonomy for decision-making from others.	The level of autonomy for each physician in each unit is full autonomy.	Each unit in healthcare centre has full autonomy for decision-making on the patient's case, as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		

Off-course yes. In our hospital, each unit works independently, but they have the same goals, especially in terms of providing good care to patients.	Each unit of a healthcare centre works independently. All have the same goals to provide a good care to patients.	Each unit of a healthcare centre works independently; but have to cooperate with others on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		
In our hospital, I think there is one database system in the statistics division; however, it is inadequate, deficient, and almost not electronic.	There is inadequate, deficient and not electronic of a healthcare information system in the hospital.	Database system for healthcare information system is incomplete.
Question (8): What are the elements of this database?		
We have some information about our patients. For example, personal information, clinical examinations, diagnoses, lab investigations, ECG, Echo, and catheterization results. For more information, all this information is paper-based.	Information system elements are patient information; but in this centre are not completed.	Some elements for healthcare information system.
Question (9): What kind of data do you need to store in the research and development unit database?		
We need name, age, sex, and occupation of the patient, which are meaning the personal information from a patient. Also, we need the information of investigations, diagnosis, managed and follow-up of the patient.	Patient information records.	To identify the elements of database system for research and development unit.
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		
In my opinion, it is better to transfer the personal, diagnostic, and therapeutic information of the patient, and transfer the results of the investigations and procedures done for the patient.	Distributed process activities of hospital on the patient treatment.	Necessity of transferring physician's activities among hospitals is to acquire new knowledge on the patients' treatment by the physicians.
Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?		
We need the information on hospital units, available services, diagnostic procedures, surgical operations, field of management, and schedules of physicians.	All physicians' activities in the patient treatment.	Necessity of the sharing of skills among physicians.
Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?		
We need the historical data of a patient to make a decision. Given a lack of doctors in our hospital, it is important to have a good database system for the sharing of information among us and with other hospitals.	Distribute of any new activities happened, especially physicians' process activities, among physicians.	Disseminate of new procedures and rare cases of patient treatment among physicians.
Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?		
Off-course yes, because it makes the research easier and accurate, and it depends on the information of our patients.	To get more information and knowledge about patients.	Necessity of navigation on the healthcare information system to get correct information and check progress.

<table>
<tr><td colspan="3">Question (14): What research and development activities would you undertake in each of the following scenarios?
-- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.</td></tr>
<tr><td>We will make a good database information electronic available in each unit.
Connecting the previous mentioned of database systems among same units is to get an information system.</td><td>Focusing on make distributed information system among healthcare units for delivering the development activities to all these units.</td><td>Necessity of distributing healthcare information among medical staff within same and different hospitals.</td></tr>
<tr><td colspan="3">Question (15): In what ways do you think in a system for integrating hospitals would be helpful?</td></tr>
<tr><td>It will be very helpful to save the patient information and to have good scientific information about patient diseases in a timely manner because the time factor is important to get data.</td><td>Integrated information system among hospitals for improving the knowledge of physicians.</td><td>Necessity of connection healthcare information systems among hospitals in order to improve the knowledge of physicians.</td></tr>
<tr><td colspan="3">Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?</td></tr>
<tr><td>Better primary and tertiary services, investigation procedure available according to the number and types of the patients.</td><td>To get new information of intervention procedure has been done for a specific disease.</td><td>Disseminate new procedures and rare cases of patients' treatment among physicians.</td></tr>
<tr><td colspan="3">Question (17): How does a physician make use of services from the research and development unit information system in his work?</td></tr>
<tr><td>To have a good information on the available disease, patients, previous diseases, drugs and investigation done for the patient to diagnose and treat the patient by easier way and to safe time as well as unnecessary tests.</td><td>To get more information and knowledge on the patient treatment and to provide a good care as soon as possible.</td><td>Improve the operation activities of physicians and provide a good care to the patients.</td></tr>
<tr><td colspan="3">Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?</td></tr>
<tr><td>We have many reasons for this issue. For example, there is a lack of appropriate medical equipment, lack of well experienced medical staff, and lack of a healthcare information system.</td><td>Poor of experience staff and healthcare information system to record the patient information.</td><td>Poor of experience staff and poor of healthcare information system.</td></tr>
<tr><td colspan="3">Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?</td></tr>
<tr><td>Yes, there are patients have many of a recurrent admitted to the hospital. For many of them, we always start again from zero point for diagnosing their cases.</td><td>Poor healthcare information system to record data about patients.</td><td>Necessity of having integrated healthcare information system.</td></tr>
<tr><td colspan="3">Question (20): How would you describe the cooperation among physicians in general?</td></tr>
<tr><td>The cooperation among physicians is not good because of, there is a lack of developed database system, lack of team or group therapy, and each physician works independently in the patient treatment.</td><td>The cooperation among physicians is poor due to a lack of information system to record physicians' activities and sharing</td><td>Necessity of distributing healthcare information system among physicians in order to improve cooperation among</td></tr>
</table>

	these activities among them.	them.
Question (21): Can we improve patient and public confidence in our healthcare services?		
By providing better services and management according to the last update scientific methods of treatment, the new instruments available and the updating of healthcare services each year.	Improve healthcare services by providing a good system to give a good care to the patients.	Necessity of having integrated healthcare information system.
Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?		
This can be done by having a good research and development unit and by providing excellent healthcare services according to the available of healthcare information system and the connection of this healthcare information system with other hospitals inside the country and also with other hospitals outside the country.	Get a new knowledge from other similar units	Necessity of connecting similar units to get more Knowledge
Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal with these threats?		
By making medical staff and physicians available, update the training program and information system.	Improve the knowledge of medical staff and provide a good information system for healthcare services.	Necessity of having a good healthcare information system to improve the knowledge of medical staff.
Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
We need an expert unit as an agent to conduct all these missions.	Agent-based system to do any job in the fast way rather than manual.	Flexible and quick adaptive to any required information as a fractal objective.
Question (25): What further requests do you need from research and development activities in your hospital?		
To start this program as easy as possible for developing a good system and connecting this system among hospitals.	Developing a system as easy as possible and connecting this system among similar centres.	Connect similar centres in order to transfer information among them.

Source: Interview
Interviewee Code: APY5
Hospital Name: Hospital A
Date and Time : 26/11/2009, 8:00pm - 9:30pm
Duration of interview: 1 $^{1}/_{2}$ hour

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
The activities of R&D are poor in our centre for reasons such as the absence of a database system with limitation of experiences, and really there is no unit to do any of these activities.	The role of R&D activities is poor in controlling of hospital's activities.	The role of R&D activities is very weak with regard to enhanced healthcare services.
Question (2): What are the objectives of the research and development unit's activities?		
According to my experience, there are many objectives doing by this unit, like to specialize in the local problems, to build up database ground for medical treatment, and to develop and manipulate of create new medical strategies.	Improvement patient treatment by creating a good healthcare information system and by developing new medical strategies.	The role of R&D activities improves healthcare services by creating healthcare information system.
Question (3): What are the benefits of the research and development unit's activities?		
The activities of this unit will improve the quality of medical services, the performance of medical staff, and will organize the medical departments' management.	This unit Improves the knowledge of researchers and physicians, and make the hospitals are trusted units.	The role of R&D activities improves physicians' performance in the patient treatment.
Question (4): Can you describe the patient treatment process in your hospital?		
In the patient treatment process, the data of a patient are accumulated from different departments such as ECG, Echo, Exercise Test, Lab Investigations, and Catheterization, then the physicians decide on the patient's case.	Focusing on the process of patients' treatment, there are many units work together in order to provide a good care to patients.	The healthcare centre's units have same goal and autonomous for decision-making, as fractal features.
Question (5): What degree of autonomy do you have for decision-making in this hospital?		
For decision-making, there is autonomy in each unit or healthcare centre to take a decision on the patient's case.	There is autonomy for each physician in each unit to make a decision on the patient's case.	Each unit in healthcare centre has autonomy for decision-making on the patient's case, as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		
Yes, they are independent units and have same goals in providing a good care to patients. The main goal of healthcare centres is to provide good healthcare services to their patients.	Each unit works independently and these units have same goals for providing healthcare services to patients.	Each unit in healthcare centre works independently; but works cooperatively with others on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		

We only have some information about our patients saved on the computer, but it is not complete, again because of the absence of a database system with limitation of experiences.	There is some information about patients on the computer.	Database system for healthcare information system is incomplete.
Question (8): What are the elements of this database?		
The elements of our system are patient records, as personal information, clinical examinations, diagnoses, lab investigations, ECG, Echo, and catheterization results. All these information are written on the paper.	Database system elements are patient records, as personal information, patient clinical examinations, diagnoses, lab investigations, ECG, Echo, and catheterization results.	To identify the elements of database system for healthcare information system.
Question (9): What kind of data do you need to store in the research and development unit database?		
I need all the information of our patients, such as (1) general information (i.e. name, age, sex, residency …etc. about a patient), (2) medical information (i.e. lab results, examination results, radiological results …etc.), and (3) results and complications of mortality of medical care.	All information related to the patients.	To identify the elements of database system for research and development unit
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		
We need to transfer the information of the type and number of physician activities, the problems and how these problems have solved by our expert physicians, especially in the patient treatment. In addition, we need to transfer new ideas and developments in instruments of the patient, and complications and challenges in the patient treatment. All I mentioned before are for getting integrated information and knowledge about the patient treatment and for seeing the global view of information of research and development units among hospitals.	Distributed Process activities of the physicians on the patient treatment among hospitals by connecting R&D units together.	Necessity of transferring hospital's activities, especially physician's activities among hospitals to acquire new knowledge on the patients' treatment.
Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?		
I think it is better to transfer the type and quantity of medical services, the new techniques in the diagnoses of patient illness, the qualifications and experience of medical staff, the results of operations, and so on… to share information on diagnoses and therapy among the medical staff, especially our doctors.	All physicians' activities on the patient treatment.	Necessity of sharing of skills among physicians within same and different hospitals.
Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?		
Recording the updates, assessment the updates and publication the updates.	Save and distribute any new activities happen among physicians.	Disseminate new procedures and rare cases of patient treatment among physicians.
Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?		
Certainly, I need to use this kind of database to get integrated information and knowledge about patient treatment, which leads to the improvement of my experience.	To get integration information and knowledge about patients.	Necessity of navigation on the healthcare information system to get correct information and check

		progress.
Question (14): What research and development activities would you undertake in each of the following scenarios? -- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.		
To determine the budget for creating some activities in the training and updating of our staff works. Informing the units regularly about suggestions from medical units to directly advise the medical staff to conduct research on new topics.	Focusing on design distributed information system for delivering the development activities to all units.	Necessity of distributing healthcare information among medical staff within same and different hospitals.
Question (15): In what ways do you think in a system for integrating hospitals would be helpful?		
This work makes the healthcare systems better by getting new strategies of work from different hospitals.	There are more benefits to integrate information system among hospitals.	Necessity of connection healthcare information systems among hospitals in order to improve the cooperation feature among physicians by sharing their skills.
Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?		
I expect that this system will be a good gate for medical research.	To get new information in order to use these information in the patient treatment and medical research.	Disseminate new procedures and rare cases of patients' treatment among physicians.
Question (17): How does a physician make use of services from the research and development unit information system in his work?		
This system directs the healthcare in the right direction and saves human resources (i.e. efforts and money) as well as controls on the diagnosis and treats the new problems.	To get new knowledge.	Improve the operation activities of physicians by acquiring new knowledge from R&D information system
Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?		
It happens due to the lack of medical equipments and units, the lack of well experienced staff and the lack of drugs and medical supplies. During our work, we mostly face difficulties in diagnosing the patient's cases due to the lack of a healthcare information system.	Lack of healthcare information system to save patient information and physician's activities.	Lack of experience staff and a healthcare information system.
Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?		
There are many cases when I needed the patient information. For example, I need the information of all investigations have done for a patient, the type of operations has done for the patient, the drugs have been taken by the patient and the family history of the patient. Therefore, I need all of these information in order to take a right decision for the patient's case.	Poor of healthcare information system to save whole information about patient.	Necessity of having integrated healthcare information system.

Unfortunately, we have not all of these details of the patient information in our current system.		
Question (20): How would you describe the cooperation among physicians in general?		
The cooperation is acceptable; but there is the lack of facilities to improve this cooperation by creating an integrated healthcare information system.	There is no system to save physicians' activities and sharing these activities among them.	Necessity of distributing healthcare information system among physicians to improve the cooperation feature.
Question (21): Can we improve patient and public confidence in our healthcare services?		
The reliability of healthcare information and researches, the good results of treatment and continuous improving in the medical care.	Provide a good experiences staff to enhance the healthcare services for patient treatment by having a healthcare information system.	Necessity of having integrated healthcare information system.
Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?		
By training the staff and getting experiences, new technologies and information from other hospitals.	Get a new knowledge from other similar units.	Necessity of connecting similar units to get more Knowledge.
Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal with these threats?		
Updating of improvement the medical standards, improvement the performance of human resources and planning for future strategies of how to facing any problems.	Apply new knowledge that has been done in other hospitals.	Necessity of connecting similar units to get more services.
Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
We would like to assign this mission to both of a group and agent.	Agent-based system to do any job in the fast way rather than manual.	Flexible and quick adaptive to any required information as a fractal objective.
Question (25): What further requests do you need from research and development activities in your hospital?		
Connection hospitals together by a website and transfer new information and knowledge among these hospitals.	Develop a system to make the connection among similar centres.	Connect similar centres in order to transfer information among them.

Source: Interview
Interviewee Code: APY6
Hospital Name: Hospital A
Date and Time : 27/11/2009, 12:00pm - 1:30pm
Duration of interview: 1 $^{1}/_{2}$ hour

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
For my information, I think there are some activities of R&D; but not in the requirement which means that these activities are poor. Sometimes be absent……. I think there is one journal in the hospital. It publishes some of our activities; however, this journal is local, as hardcopy, not available online as softcopy.	The role of R&D activities is poor in order to control on the physician's activities and publishing these activities among them.	The role of R&D activities is poor with regard to improved physicians' skills and enhanced healthcare services.
Question (2): What are the objectives of the research and development unit's activities?		
If this unit found, first we should have been filing system of our work and patient in order to do a research for improving healthcare services in our hospital. Furthermore, patient information will show us this patient got the benefit from our treatment or not. In case of a patient did not get any benefit, we should diagnose this problem.	Improvement of the patient treatment is by developing healthcare information system and sharing this information among physicians.	The role of R&D unit activities improves the operation activities of physicians for patient treatment by sharing these activities among physicians in the hospital.
Question (3): What are the benefits of the research and development unit's activities?		
The benefits are to decrease the mistake of our work, to improve medical care, to increase knowledge of the doctor.	Improve the knowledge of researchers and physicians, and make the hospitals are trusted units.	The role of R&D unit activities improves physicians' skills.
Question (4): Can you describe the patient treatment process in your hospital?		
We have two types of patients (i.e. outpatient and inpatient). The procedure of outpatient treatment starts from consultation units to record personal information and examination test. Then send a patient either to medical treatment only or to other units, such as ECG, Echo, Exercise Test and Lab Investigations, for more investigations about the patient's case. After that, we also send our patient either to medical treatment only or to Catheterization unit in order to get more information to have a right decision to diagnose our patient's case and give him/her a good treatment. By the way, this procedure depends on the physicians experienced. Furthermore, for the inpatient, he/she already has recorded his/her information in the hospital. Then, may be the inpatient will be in the CCU (i.e. Coronary care unit) or in the heart unit to take a care in the hospital. Such patients we will do all the above-mentioned tests like outpatient; but also it depends on the physician's experienced and patient's illness. Further, if the healthcare information system found, the file system of patient starts to record by the admission room or consultation unit. However, our system is wrong for recording our patient records. The structure of units for patient care process is depending on the physician's decisions.	Focusing on the procedure of patient treatment, there are many units work together in order to provide a good care to patients. In addition, the structure of these units has a bottom-up process.	The healthcare centre's units have same goal and autonomous for decision-making. In addition, the structure of these units has a bottom-up process, as the fractal approach.

Question (5): What degree of autonomy do you have for decision-making in this hospital?		
For this issue, there are two levels. First, we haven't autonomy on the management issues. Second, we have full autonomy to make a decision of the patient treatment.	The level of autonomy for each physician in each unit is full autonomy to make a decision of the patient treatment	Each unit in the healthcare centre has full autonomy for decision-making of the patient treatment as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		
Yes, surely these centres have independent units and all of them are doing same work, especially in the patient treatment.	Each unit works independently and has the same goals for the patient treatment.	Each unit in a healthcare centre works independently; but have cooperation with others on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		
We haven't a good database in our centre, because of our file system is bad and data recording system is also bad. Sometimes, we lose much information about our patient due to lose and damaged some of paper that related to our patient information. This happens due to most of our work is paper-based not computerized. Furthermore, we haven't good staff for data enter and this staff should be a doctor in order to know how to enter these data. In addition, the time factor also affects our work because this centre is very busy. It has many patients and a limited number of doctors. For that, there is no time to record the data of patients.	There is some information about patients on the computer and others on the papers.	Database system for healthcare information system is incomplete.
Question (8): What are the elements of this database?		
Our database elements are very weak, and only we have patient information, as personal information, clinical examinations, diagnoses, lab investigations, ECG, Echo, Exercise testing and catheterization results; however, most of these information saved on the paper.	Database system elements are patient information, as personal information, patient clinical examinations, diagnoses, lab investigations, ECG, Echo, Exercise test and catheterization results.	To identify the elements of database system for healthcare information system.
Question (9): What kind of data do you need to store in the research and development unit database?		
We need all information related to patients (i.e. all investigations, diagnosis, treatment, prognosis, and so on), and related to physicians to be saved in this unit.	Patient information and physicians information.	To identify the elements of database system for research and development unit.
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		
All information related to the patient can be distributed among hospitals to be available to all physicians in the system. The physicians can exchange advice among each other to share their skills. It is good to see the global view of information among hospitals.	Distributed process activities of a hospital on the patient treatment.	Necessity of transferring physicians' activities among hospitals is to acquire new knowledge on the patient treatment.

Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?		
In my opinion, we have to transfer the summary of physicians' work, the ways of treatment, and simple statistical information about patients. Furthermore, we need all information related to the patient to be transferred among physicians. If we have a database for patient records, we can make a copy of data and provide these data to the patient by CDs. This work will reduce the effort of a patient to do more other investigations and reduce the work of a physician in the diagnosis of a patient case. But now, we have lost of money and have many problems in our system, like if the patient lost reports on his/her case, we should make another new investigation. It is waste of time and effort of the patient and the physician.	All physicians' activities on the patient treatment.	Necessity of the sharing of skills in the patient treatment among physicians.
Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?		
I need many things, like the historical data of patient and the discussion with other doctors in my field for any new case happened in order to get more knowledge from other doctors.	The sharing of knowledge among physicians on the new activities happened.	Disseminate new procedures and rare cases of patient treatment among physicians.
Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?		
This is important to do my research and get more knowledge for improving my work.	To get integrated information and knowledge about patients.	Necessity of navigation on the healthcare information system to get correct information and check progress.
Question (14): What research and development activities would you undertake in each of the following scenarios? -- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.		
To supply more medical units and cardiac surgeons, such as building the surgery unit in our hospital because this unit is not ready yet. Due to the lack of connection among hospital units, I plan to create and implement a healthcare information system among staff in this hospital and in other hospitals.	Focusing on design distributed information system for delivering the development activities to all units.	Necessity of distributing healthcare information among medical staff within same and different hospitals.
Question (15): In what ways do you think in a system for integrating hospitals would be helpful?		
To see the information of activities in hospitals, it needs to connect the information systems of these hospitals together which lead to improve the collaboration among medical staff. Also, it will be a beneficiary to get information if the patient went to other hospitals in the system.	There are more benefits to integrate an information system among hospitals.	Necessity of connection healthcare information systems among hospitals in order to improve the cooperation feature among physicians by sharing their skills.
Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?		

In my opinion, I have to get the information of our patient treatment and timetable for doctors. Furthermore, it is important to get the information in the fast ways about activities have been done locally and/or globally.	To get new information of intervention procedure has been done for a specific disease.	Disseminate of new procedures and rare cases of patients' treatment among physicians.
Question (17): How does a physician make use of services from the research and development unit information system in his work?		
I can get data and do research in order to improve our knowledge and healthcare.	To get new knowledge	Improve the operation activities of physicians
Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?		
We have in many times due to deficiency of experienced medical staff in some units, poor in equipments or medical units and weak at a healthcare information system.	Deficiency of experience staff in some units and deficiency of a healthcare information system to save patient information and physician's activities.	Deficiency of experience staff and of a healthcare information system.
Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?		
I need every time all information about my patients, especially to follow up my patients with documentation; but in many times I couldn't find some information about my patient.	Poor of healthcare information system to record the data of patients.	Necessity of having integrated healthcare information system.
Question (20): How would you describe the cooperation among physicians in general?		
The cooperation among doctors is not bad, and at the same time is not good. This happens because of time. There is no time to make any meeting among doctors for discussion or sharing of skills. Also, there is no system to distribute information among them.	The time impact on the cooperation among doctors. There is no system to save the activities and distributed these activities among staff.	Necessity of distributing healthcare information system among physicians due to the time factor.
Question (21): Can we improve patient and public confidence in our healthcare services?		
To provide a good care to the patient and a good data recording for the patient.	Creating integrated healthcare information system.	Necessity of having integrated healthcare information system.
Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?		
We have to improve our data system and health education for general purposes, and we have to healthcare information system with	Get a best knowledge from other hospitals.	Necessity of connecting hospitals together in order to get more Knowledge.
Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal with these threats?		
For this issue, our hospital faces threat of recording system. There is a bad recording system for saving data, as developed countries, and distributing information among doctors. Here, we have good healthcare and doctors; but unfortunately, our recording system is imperfect.	Develop a good record system and distribute information among physicians within same and different hospitals.	Necessity of connecting similar units to improve healthcare services.

Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
An agent-based system is better to undertake this mission in a fast way.	Agent-based system to do any job in the fast way rather than manual.	Flexible and quick adaptive to any required information as a fractal objective.
Question (25): What further requests do you need from research and development activities in your hospital?		
My request is to organize our work in order to show t statistical information monthly about how many patients we have, how many patients died, operation results and ……..etc.	To monitor physicians' activities and showing the results of these activities.	Control on the physician's activities and distributed the results of these activities among physicians.

Source: Interview
Interviewee Code: BPY1
Hospital Name: Hospital B
Date and Time : 16/11/2009, 10:30 am -11:30 am
Duration of interview: 1 hour

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
We have this unit in our centre. We have a meeting every week, and we discuss the difficult cases and other activities. The diagnoses and type of management include referral of a patient by the committee. Also, there is joint conference between surgeons and physicians. It is like a conference; but the activities still weak in order to have a good healthcare information system to share with other centres.	The role of R&D activities to somehow is good to control on the physician's activities and sharing these activities with others; but only in the discussion meeting.	The role of R&D activities is weak with regard to improve physicians' skills and enhance healthcare services.
Question (2): What are the objectives of the research and development unit’s activities?		
To get a complete database of our patient records, this will facilitate statistical and follow up in the future.	Improvement patient treatment by developing a good healthcare information system.	The role of R&D activities improves the operation activities of physicians for treating patients by developing a good healthcare information system.
Question (3): What are the benefits of the research and development unit’s activities?		
To minimize the process if the patient visiting to our centre or to other centres.	Provide information of the patient to the physicians to minimize the process of patient treatment.	The role of R&D activities improves physicians' work.
Question (4): Can you describe the patient treatment process in your hospital?		
When our patient comes to the hospital, the process begins from the reception room (admission room) where the personal information about the patient is entered, and then the patient is sent to the consultation units. Furthermore, we send our patients either to the medical treatment or non-invasive units to obtain more information about the case. Thereafter, we also send our patient either to medical treatment or invasive unit to get more information that would lead to a right decision to diagnose the patient’s case. Finally, we conduct either therapeutic catheterization or surgery, if necessary. Sometimes, the patient has been sent from another centre, in which case we just look at the patient’s reports and depending upon the results, we provide him/her with the best treatment. The previous work is similar to a process that goes through multiple levels of units to provide good care to the patients.	Focusing on the process of patients' treatment, there are many units work together in order to provide a good care to patients. These processes are going through multi level of units, as bottom-up process.	The healthcare centre’s units have same goal and autonomous for decision-making. In addition, the structure of these units has bottom-up process, as the fractal approach.
Question (5): What degree of autonomy do you have for decision-making in this hospital?		

In our centre, we have autonomy for any decision-making, especially on our patients.	There is autonomy for each physician to make a decision on the patient's case.	Each unit in healthcare centre has full autonomy for decision-making on the patient's case, as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		
Yes, each unit in our centre works independently, and these units work together to come up with a good decision on the patient's case to provide the best quality of care.	Each unit works independently and has the same goals.	Each unit in healthcare centre works independently; but have cooperation with others on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		
In our centre, we have an intranet database system, but it is local, centralized and only for our patient records. We can see our patients' information in order to use it in the follow up.	There is an electronic patient record in the centre; but not in the requirement.	Database system for healthcare information system is incomplete.
Question (8): What are the elements of this database?		
We have an intranet system contains personal and picture of patients, diagnosis dates, and any surgical or catheterization has been done for the patient. Also, this system contains a date of laboratory investigations, Echo and treatment (i.e. medication).	Database system elements are patient information, as personal information, diagnoses, lab investigations, Echo, and catheterization or surgical.	To identify the elements of database system for healthcare information system.
Question (9): What kind of data do you need to store in the research and development unit database?		
Patient history, clinical examinations, lab, Echo, X-ray, previous referrals to non-invasive units, then invasive unit (i.e., catheterization results), and intervention or surgery information and/or just medical treatment.	Patient information and physicians work.	To identify the elements of database system for research and development unit.
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		
To get the update of ways in management and treatment. Furthermore, it can be done by working and bringing the new devices of treatments.	Distributed process activities of hospital on the patient treatments.	Necessity of transferring hospital's activities among hospitals to acquire new knowledge on the patients' treatment.
Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?		
Provisional diagnosis of a patient, and a final diagnosis plan for management and treatment advice are crucial, Why I said advices, because the patient may not be satisfied with our diagnosis. Then he says, 'I will go abroad (i.e., to another centre) to take medical treatment instead of going through the surgery that you suggested'. The statistics information also need to show the results include morbidity and mortality, and the equipment used in diagnosis and intervention or surgery.	All physicians' activities on the patient treatment.	Necessity of sharing of skills among physicians.
Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?		

The patient medical record and for this process is should be studied and analyzed in the regular weekly meeting joint to decide the case.	Distribute any new activities happened, especially physicians' process activities, among physicians.	Disseminate new procedures and rare cases of patient treatment among physicians.
Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?		
It is very important to have a database, because it will help me to get more information and knowledge to do my research easily and accurately.	To get integration information and knowledge about patients.	Necessity of navigation on the healthcare information system to get correct information and check progress.
Question (14): What research and development activities would you undertake in each of the following scenarios? -- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.		
We need professional staff and a special unit to deal with any healthcare information development for providing a good healthcare system because there is not enough time for physicians to do everything. I have to disseminate new information (i.e., about new operations) in a short time to the various units for sharing among medical staff.	Focusing on design distributed information system for delivering the development activities to all units.	Necessity of distributing healthcare information among medical staff within same and different hospitals.
Question (15): In what ways do you think in a system for integrating hospitals would be helpful?		
It will be helpful for providing a good care to the patients. Also, could be useful for finding more information about patients and illness and how these illnesses have been treated, which lead to improve physicians' knowledge.	The main benefit is to improve physicians' skills by integrating healthcare information system among hospitals.	Necessity of connection healthcare information systems among hospitals in order to improve the cooperation feature among physicians by sharing their skills.
Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?		
It is beneficial to know about the morbidity and for follow up as well as to provide the patients with better diagnostic and therapeutic services.	To get new information of intervention procedure has been done for a specific disease.	Disseminate new procedures and rare cases of patients' treatment among physicians.
Question (17): How does a physician make use of services from the research and development unit information system in his work?		
When more centres were connected together, we can share even the treatment advices and teaching purposes.	Acquiring a new knowledge from other centres.	Improve the operation activities of physicians.
Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?		
In our centre, we have many reasons. For instance, there is a lack of medical units, maybe a lack of well experienced staff and poor in a healthcare information system.	Poor of experience staff and healthcare information system to save all physician activities.	Poor of experience staff and poor of healthcare information system.

Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?		
Yes, sometimes we ask patient, if he/she not our patient, to bring the case sheet or report from the previous centre. If there is no report, we will do everything from zero, which means it take a time and more costs. This is a main problem in our statistical centre in often they throw old documents about patients because of difficulty to control and manage a paper-based information vs. computer-based information.	Need to have Healthcare information system to save whole information about patients.	Necessity of having integrated healthcare information system.
Question (20): How would you describe the cooperation among physicians in general?		
The cooperation to somehow it is good in our centre; but it depends on the field of work and time factor.	The sharing of activities is not satisfying among physicians.	Necessity of distributing healthcare information system among physicians.
Question (21): Can we improve patient and public confidence in our healthcare services?		
Choosing the best equipments, lab facilities, diagnoses and treatment and a good system to record every activity in our centre.	Creating integrated healthcare information system.	Necessity of having integrated healthcare information system.
Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?		
We should have a teaching program for the local team and the team from other centres, but the time factor is significant for all physicians and patients. Therefore, it is important for centres to have a connection that can enable them to share the ideas and information.	Get a new knowledge from other similar units.	Necessity of connecting similar units to get more Knowledge.
Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal with these threats?		
By conferences to discuss, analyse and solve the problems.	Applying new knowledge that has been done in other hospitals	Necessity of connecting similar units to get more services
Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
To an agent, this mission should be done effectively and quickly because the time factor is important.	Agent-based system to do any job in the fast way rather than manual.	Flexible and quick adaptive to any required information as a fractal objective.
Question (25): What further requests do you need from research and development activities in your hospital?		
The best database that is considered in an advanced centre abroad to see their experiences and their problems.	Developing a cooperative healthcare information system among similar centres.	Connect similar centres in order to transfer information among them.

Source: Interview
Interviewee Code: BPY2
Hospital Name: Hospital B
Date and Time : 17/11/2009, 10:00 am -11:00 am
Duration of interview: 1 hour

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
For these activities, we are starting now. We have a consultation meeting weekly; we discuss the difficult cases of our patients, and how we can treat these cases.	The role of R&D activities is to provide a good care to the patients.	The role of R&D activities is to improve the patient treatment.
Question (2): What are the objectives of the research and development unit's activities?		
It is to treat cardiac patients, medically or by intervention of the surgical treatment together with the preventing heart disease in susceptible patients.	Improvement patient treatment by sharing physicians' activities in the hospital.	The role of R&D activities improves the operation activities of physicians for treating patients by sharing these activities among physicians in the hospital.
Question (3): What are the benefits of the research and development unit's activities?		
The benefits of R&D unit activities include updating our knowledge and providing better treatment for patients by enabling us to see the results of any patient, which will give the patient a good management depending upon the results.	Improve the knowledge of physicians on the patient treatment.	The role of R&D activities improves physicians' skills.
Question (4): Can you describe the patient treatment process in your hospital?		
This process starts from the reception unit, then the consultation unit, then to the non-invasive units to obtain more information about the patient's case. Then, we send our patient either to medical treatment or to an invasive unit to obtain more information to have the right decision to diagnose our patient's case. Finally, we send our patient to the surgery unit, if the patient requires surgery.	Focusing on the process of patients' treatment, there are many units work together in order to provide a good care to patients.	The healthcare centre have many units work together to provide a good care to the patient, as the fractal approach.
Question (5): What degree of autonomy do you have for decision-making in this hospital?		
In most times, we have autonomy in decision making on patient treatment from other units or from other hospitals. Sometimes we have a committee that discusses a decision on the patient's case to provide a good treatment.	The level of autonomy for each physician in each unit is full autonomy to make a decision on the patient treatment.	Each unit in healthcare centre has full autonomy for decision-making on the patient treatment, as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		
Yes, they are independent units with the same goals of managing patients.	Each unit works independently and has the same goals for managing patients.	Each unit in healthcare centre works independently; but have cooperation with others on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		

We have a database in our hospital; but it is simple and only we have patient records. We have an intranet to connect departments within the hospital in order to see the patient information in each department.	There is database system have information about patients.	Database system for healthcare information system is incomplete.
Question (8): What are the elements of this database?		
The elements are historical information of patients, investigations and therapies.	Database system elements are patient information, as personal information, patient clinical examinations, diagnoses, investigations and therapies.	To identify the elements of database system for healthcare information system.
Question (9): What kind of data do you need to store in the research and development unit database?		
All information related to a patient. For example, clinical examinations, investigations including (echo, information about the cath. Lab) and surgical treatment and follow up, all these activations with physician information to know who the previous work did.	Patient information and physicians' information.	To identify the elements of database system for research and development unit.
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		
We need to transfer specific information of a patient, because in our centre, we have difficulty in managed specific type of patients, particularly in Pediatric department. Therefore, It is best to transfer number of patients, types of treatment, and results of treatment and follow up. Furthermore, it is better to have a global perspective about the activities among hospitals.	Distributed process activities of hospital on the patient treatment.	Necessity of transferring hospital's activities among hospitals to acquire new knowledge on the patients' treatment.
Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?		
In our hospital, we introduce the update management of foreign teams from many countries such as the Netherlands. When these teams come to our centre, they share with us the modern treatment procedures in the surgical and medical management of patients. Also, they help us to treat the difficult cases that we did not have the experience to handle. For that, we need to transfer the information of the work of physicians on the patient treatment among hospitals to acquire new knowledge from other physicians.	All physicians' activities on the patient treatment.	Necessity of sharing of skills among physicians.
Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?		
Again, all the information about a patient starting from the history, investigations (particularly, the modern type of investigations that affect the treatment and prognosis of the patient), and the types of treatment.	Distribute the new activities happened, especially physicians' process activities, among physicians.	Disseminate new procedures and rare cases of patient treatment among physicians.
Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?		
I need to do that, because one of the main aims of this system is for research to improve our knowledge and work.	To get integration information and knowledge about patients.	Necessity of navigation on the healthcare information system to get correct information and check

		progress.
Question (14): What research and development activities would you undertake in each of the following scenarios? -- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.		
We Try to keep all the reports (the previous one and the next one) of a patient available in the centre in order to compare with the treatment, and we try to cooperate with other physicians outside the hospital in order to select cases for better management; because outside this hospital, the cardiologists may not know, which is the best treatment to this group of patients. We have to summary the details of information about patients and to distribute these details to all units.	Focusing on the development of a distributed information system for delivering the activities to all units.	Necessity of distributing healthcare information among medical staff within same and different hospitals.
Question (15): In what ways do you think in a system for integrating hospitals would be helpful?		
Integrated healthcare information systems among hospitals could be very helpful in acquiring more knowledge about the best treatment and improving collaboration among medical staff.	The integrated information system among hospitals could improve the cooperation among medical staff.	Necessity of connection healthcare information systems among hospitals in order to improve the cooperation feature among physicians by sharing their skills.
Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?		
Information about the incidence of the disease and how this disease progress and how our treatment or management is effective and how our people are aware of their health.	To get new information of intervention procedure has been done for a specific disease.	Disseminate new procedures and rare cases of the patient treatment among physicians.
Question (17): How does a physician make use of services from the research and development unit information system in his work?		
It is an easy process; every unit has its detail of information besides files of patients are available.	To get new knowledge.	Improve the operation activities of physicians.
Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?		
In our hospital, we have well medical equipments and units; but there is a lack of well experienced medical staff.	Poor of experience staff.	Poor of experience staff.
Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?		
Yes, We have some of the rare cases when we needed to diagnosis the case.	Weak Healthcare information system to save whole information about patient.	Necessity of having integrated healthcare information system.
Question (20): How would you describe the cooperation among physicians in general?		

In our centre we have good cooperation among physicians but weak cooperation with other physicians outside this centre.	There is weak cooperation among physicians' activities from different centres.	Necessity of distributing healthcare information system among physicians within same and different hospitals.
Question (21): Can we improve patient and public confidence in our healthcare services?		
Yes, we can do that by giving patients a best management and advising them with a good medical treatment.	Best management of healthcare information system for patients.	Necessity of having integrated healthcare information system.
Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?		
By training our staff and give them a good advices; because our hospital became a teaching hospital now. For that, again we would like to provide and get experience staff from in or outside to provide and get more information about the patient treatment.	Provide and get a new knowledge of the patient treatment from other similar units.	Necessity of connecting similar units to provide and get more Knowledge.
Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal with these threats?		
There is a plan practically in the surgical department to prevent infection; but only locally in our hospital. We haven't any connection system with other hospitals to see what they did in this issue and so on.	Need to get a new knowledge that has been done in other hospitals.	Necessity of connecting similar units to get more services.
Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
I would like to assign this mission to an agent in the computer, but with the best supervision.	Agent-based system to do any job in the fast way rather than manual.	Flexible and quick adaptive to any required information as a fractal objective.
Question (25): What further requests do you need from research and development activities in your hospital?		
We lack the equipment necessary in patient treatment, and we need much more experience, particularly by connecting with medical professionals outside this hospital to obtain more knowledge about patient treatment.	Developing a system to connect among similar centres.	Connect similar centres in order to transfer information among them.

Source: Interview
Interviewee Code: BPY3
Hospital Name: Hospital B
Date and Time : 17/11/2009, 12:00 pm -1:00 pm
Duration of interview: 1 hour

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
We have in this unit a consultation meeting weekly to discuss some difficult cases of our patients and how we can treat these cases.	The role of R&D activities is to provide a good care to the patients.	The role of R&D activities is to improve the patient treatment.
Question (2): What are the objectives of the research and development unit's activities?		
The main objective of this unit is to provide and gather data for visiting patients with information of diagnosis, treatment, and surgery to make the work of doctors easier and faster.	Improvement patient treatment by sharing physicians' activities in the hospital.	The role of R&D activities improves the operation activities of physicians for treating patients by sharing these activities among physicians in the hospital.
Question (3): What are the benefits of the research and development unit's activities?		
It is to follow up and treat a patient in the complete way by updating our knowledge and providing a better treatment for the patients.	Improve the knowledge of physicians on the patient treatment.	The role of R&D activities improves physicians' skills.
Question (4): Can you describe the patient treatment process in your hospital?		
It starts from reception unit, then consultation unit, next the diagnoses and type of management of the patient done by the special physician and takes a decision for medical, therapeutic catheter and/or surgical treatment.	Focusing on the process of patient treatment, there are many units work together in order to provide a good care to patients.	The healthcare centre have many units work together to provide a good care to the patient, as the fractal approach.
Question (5): What degree of autonomy do you have for decision-making in this hospital?		
Again, the autonomy is on the diagnoses and type of management of the patient, which means that the physician takes a decision for medical or other treatments, as mentioned previously.	The level of autonomy for each physician in each unit is full autonomy to make a decision on the patient treatment.	Each unit in healthcare centre has full autonomy for decision-making on the patient treatment, as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		
Off-course yes, they are independent units with the same goals of managing patients.	Each unit works independently and has the same goals for managing patients.	Each unit in healthcare centre works independently; but have cooperation with others on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		

There is a database in our hospital and there is an intranet to connect departments of the hospital together to see the patient record in each department.	There is database system have information about patients.	Database system for healthcare information system is incomplete.
Question (8): What are the elements of this database?		
The elements of our information system are the patient information and some investigations and therapeutic.	Database system elements are patient information, as personal information, patient clinical examinations, diagnoses, investigations and therapies.	To identify the elements of database system for healthcare information system.
Question (9): What kind of data do you need to store in the research and development unit database?		
the historical information of patient, examinations, lab investigations, Echo, X-ray, cardiac catheterization and treatment, which means all activities on the patient by our medical staff, especially physicians.	Patient information and physicians' information.	To identify the elements of database system for research and development unit.
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		
We would like to have a healthcare information system among hospitals in order to share the information of diagnoses, types of treatment, schedule of doctors.	Distributed process activities of hospital on the patient treatment.	Necessity of transferring hospital's activities among hospitals to acquire new knowledge on the patients' treatment.
Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?		
Also again, we need to transfer all the previous mentioned information with statistical information of the performance of surgical results and medical treatments on our patients.	All physicians' activities on the patient treatment.	Necessity of sharing of skills among physicians.
Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?		
With regard to this issue, we have weekly meetings for all activities and cases of our patients and the new processes done by our staff.	Distribute the new activities happened, especially physicians' process activities, among physicians.	Disseminate new procedures and rare cases of patient treatment among physicians.
Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?		
I would like to do that to obtain more information about the patient treatment to improve our knowledge and work.	to get integration information and knowledge about patients.	Necessity of navigation on the healthcare information system to get correct information and check progress.
Question (14): What research and development activities would you undertake in each of the following scenarios? -- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.		
We need professional persons and special unit for dealing with these data. I would like to have a good system to disseminate information in a short time among units.	Focusing on the development of a distributed information system for delivering the activities to all units.	Necessity of distributing healthcare information among medical staff within same and different hospitals.

<table>
<tr><td colspan="3">Question (15): In what ways do you think in a system for integrating hospitals would be helpful?</td></tr>
<tr><td>This integration will be helpful to share information among medical staff in order to get more knowledge about the patient treatment.</td><td>The integrated information system among hospitals could improve the cooperation among medical staff.</td><td>Necessity of connection healthcare information systems among hospitals in order to improve the cooperation feature among physicians by sharing their skills.</td></tr>
<tr><td colspan="3">Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?</td></tr>
<tr><td>I expect to know the information about patients and type of services included surgical and/or medical treatment.</td><td>To get information of the procedures have been done for a specific diseases.</td><td>Disseminate new procedures and rare cases of the patient treatment among physicians.</td></tr>
<tr><td colspan="3">Question (17): How does a physician make use of services from the research and development unit information system in his work?</td></tr>
<tr><td>When more centres connected together we can get more information and advices for all situations.</td><td>To get new knowledge.</td><td>Improve the operation activities of physicians.</td></tr>
<tr><td colspan="3">Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?</td></tr>
<tr><td>Sometimes, this happens due to the lack of medical units, the weak of experience staff to diagnose difficult cases and the lack of a distributed information system among hospitals.</td><td>Poor of experience staff and distributed healthcare information system.</td><td>Poor of experience staff and distributed healthcare information system.</td></tr>
<tr><td colspan="3">Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?</td></tr>
<tr><td>In sometimes I have to know the historical information of a patient in order to diagnose his/her case in the right way.</td><td>The healthcare information system is important to diagnose any patient case.</td><td>Necessity of having integrated healthcare information system.</td></tr>
<tr><td colspan="3">Question (20): How would you describe the cooperation among physicians in general?</td></tr>
<tr><td>In our centre, we have a good cooperation among physicians and weak with others outside this centre.</td><td>There is weak cooperation among physicians' activities from different centres.</td><td>Necessity of distributing healthcare information system among physicians within same and different hospitals.</td></tr>
<tr><td colspan="3">Question (21): Can we improve patient and public confidence in our healthcare services?</td></tr>
<tr><td>Yes, by Choosing the best services and good medical advices for a patient as well as by developing a healthcare information system in order to record the patient information.</td><td>Best management of healthcare information system for patients.</td><td>Necessity of having integrated healthcare information system.</td></tr>
<tr><td colspan="3">Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?</td></tr>
<tr><td>Good teaching staff and sharing all information among them and other units.</td><td>Provide and get knowledge on the patient treatment from other similar units.</td><td>Necessity of connecting similar units to provide and get more Knowledge.</td></tr>
<tr><td colspan="3">Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal with these threats?</td></tr>
</table>

Organize conferences and/or system in order to share all activities and problems to solve it.	Need to get a new knowledge that has been done in other hospitals.	Necessity of connecting similar units to get more services.
Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
To an agent in the computer is better.	Agent-based system to do any job in the fast way rather than manual.	Flexible and quick adaptive to any required information as a fractal objective.
Question (25): What further requests do you need from research and development activities in your hospital?		
It is better to connect database system among same centres to get more information such as medical and surgical treatment information.	Developing a system to connect among similar centres.	Connect similar centres in order to transfer information among them.

Source: Interview
Interviewee Code: BPY4
Hospital Name: Hospital B
Date and Time : 18/11/2009, 8:00 pm -9:30 pm
Duration of interview: 1 1/2 hour

Question (1): I understand that there is growing interest in research and development unit in your hospital. Can you tell me something about what is happing in your hospital with regard to research and development activities?		
Response	Initial Coding	Focussed Coding
Until now, I have no idea about this unit and its activities, we have or not.	This is meaning that the role of R&D activities is weak in the hospital.	The role of R&D activities is weak in the hospital.
Question (2): What are the objectives of the research and development unit's activities?		
In my opinion, it helps the physicians to reach the information about patients in order to use it in their work.	Improvement patient treatment by distributing physicians' activities on the patients in the hospital.	The role of R&D activities improves the operation activities of physicians for treating patients by sharing these activities among physicians in the hospital.
Question (3): What are the benefits of the research and development unit's activities?		
It is making a treatment better.	Enhance the patient treatment.	The role of R&D activities enhances the patient treatment.
Question (4): Can you describe the patient treatment process in your hospital?		
It starts from consultation units, then we send patient either to medical treatment and/or to non-invasive units (i.e. ECG, Echo, Exercise Test, Lab Investigations, and so on) to get more information. After that, we also send our patient either to medical treatment and/or invasive unit (i.e. Catheterization unit) to get more information. Depending on the previous information we make a final decision on the patient's case. These data should be transfer among these units is like bottom-up process to provide a right care to any patient.	Focusing on the process of patients' treatment, there are many units work together in order to provide a good care to patients. In addition, the structure of these units has bottom-up process.	The healthcare centre's units have same goal and autonomous for decision-making. In addition, the structure of these units has bottom-up process, as the fractal approach.
Question (5): What degree of autonomy do you have for decision-making in this hospital?		
In some parts of work, it is yes (e.g. to t a decision on the patient's case), but in great parts of work need upper office like the ministry of healthcare.	There is autonomy on the patient treatment.	Each unit in healthcare centre has full autonomy for decision-making on the patient's case, as fractal features.
Question (6): Do healthcare centres comprise independent units and do they have the same goals?		
In my point of view yes, they are independent; but maybe have different goals. In general, all of these centres want to help patients.	Each unit works independently and has the same goals for patient treatment.	Each unit in healthcare centre works independently; but have cooperation with others on the patient treatment, as fractal features.
Question (7): If you have a database in your hospital, can you tell me something about it?		
I have no idea about the database. Maybe, there is one, but I haven't used it until now.	There is some information about patients.	Database system for healthcare information system is incomplete.

Question (8): What are the elements of this database?		
I don't know.	Database system elements are not clear.	To identify the elements of database system for healthcare information system.
Question (9): What kind of data do you need to store in the research and development unit database?		
Patient information, treatments, results, time duration of staying in the hospital and so on.	Patient information and activities done by the physicians.	To identify the elements of database system for research and development unit.
Question (10): If you are a director of the hospital, physician in the control and planning of healthcare service activities, what information do you need to transfer between hospitals with regard to improved hospital activities?		
The details of our management like number of employees and instruments and so on.	Distributed process activities of hospital.	Necessity of transferring hospital's activities among hospitals to acquire new knowledge.
Question (11): What information do you need to transfer between hospitals with regard to improved quality of patient treatment?		
The details, as out treatment and operations and their results.	All physicians' activities on the patient treatment.	Necessity of sharing of skills among physicians.
Question (12): When any update happens in the patient treatment process, what kind of information do you need for decision making during this process?		
Bringing new instruments, drugs and works, as developing a distributed information system among hospitals in order to see the results of any operation, which leads to improve the cooperation among physicians by sending the patient with each other.	Distribute any new activities happened, especially physicians' process activities, among physicians.	Disseminate new procedures and rare cases of patient treatment among physicians.
Question (13): In your own research, why do you need to use and access the database of hospital that contains the patient historical information and the hospital activities?		
It is better to have it for global research, and not only for local research in our hospital.	To get integration information and knowledge about patients over different hospitals.	Necessity of navigation on the healthcare information system to get correct information and check progress.
Question (14): What research and development activities would you undertake in each of the following scenarios? -- You are given responsibility for development of your hospital healthcare services. - As coordinator of research teams in your hospital, you are responsible for disseminating the results of new patient treatments to all units in a timely manner.		
To put data about medical staff and patients in the distributed system. I need information about patients and separate medical teams.	Focusing on the development a distributed information system for delivering the development activities to all units.	Necessity of distributing healthcare information among medical staff within same and different hospitals.
Question (15): In what ways do you think in a system for integrating hospitals would be helpful?		
Every integration information system is helpful to make the patient treatment better.	Integration information system among hospitals enhances the patient treatment	Necessity of connection healthcare information systems among hospitals in order to improve the healthcare services.

Question (16): If you have a research and development unit information system in your hospital, what health services do you expect from the system?		
I expect to get information from other physicians' work and connect them together in order to exchange their ideas and results of work with each other.	To get new information of procedures has been done by physicians from different hospitals.	Disseminate new procedures and rare cases of patients' treatment among physicians.
Question (17): How does a physician make use of services from the research and development unit information system in his work?		
It will progress in the scientific level of hospital by sharing physicians' activities together in order to get new knowledge.	To get new knowledge.	Improve the operation activities of physicians.
Question (18): In every hospital, there are times when we are unable to provide quality patient treatment for a variety of reasons. In your experience, what have been some of these reasons for less than high-quality treatment?		
There are many reasons. Like there is a lack of appropriate medical equipments, there is also a lack of experience staff in our hospital and lack of a good healthcare information system.	Poor of experience staff and healthcare information system.	Poor of experience staff and poor of healthcare information system.
Question (19): If you have encountered cases when you needed patient history to address the case, please give me some examples?		
In many cases having a history of treatment and progress disease is important; but our information system is a weak to address everything. So that, we do more investigations again on the patient's case.	Poor Healthcare information system to save whole information about patient.	Necessity of having integrated healthcare information system.
Question (20): How would you describe the cooperation among physicians in general?		
Between towns, there is no cooperation but in a hospital it is good but without any connection techniques just personally.	There is no system to save physicians' activities and sharing among them.	Necessity of distributing healthcare information system among physicians.
Question (21): Can we improve patient and public confidence in our healthcare services?		
Surely yes, it can be done by giving true information and results through developing a good healthcare information system.	Creating integrated healthcare information system.	Necessity of having integrated healthcare information system.
Question (22): When development opportunities arise for a hospital, how can we make best exploit (use) of such opportunities?		
By getting help from the other experiences.	Get knowledge from other similar units.	Necessity of connecting similar units to get more Knowledge.
Question (23): When a hospital faces threats to its services and facilities, how do you think we can deal with these threats?		
I don't know.	There is no any idea.	There is no any idea.
Question (24): When research and development activities are being developed in the hospital, would you like to have managed and controlled these activities by a group of people or by agent-based system?		
To a group working, because the possibility of mistakes happen.	Doing by group of people instead of computer to prevent any mistake happens by computer.	Manual work on the activities.
Question (25): What further requests do you need from research and development activities in your		

hospital?		
Good work, relation and true information to share among different hospitals.	Develop the connection among similar centres.	Connect similar centres in order to transfer information among them.

APPENDIX C

Physician Evaluation Questionnaire

There are two goals to this questionnaire. First, to evaluate the usability of Fractal-based Healthcare Information System (FHIS) by physicians. Second, to evaluate to what extent dose the FHIS improve the level of cooperation among physicians with regard to the sharing of information and skills in the patient treatment within the hospital environment.

This questionnaire is divided into three sections:

Section A: System usability scale of the effectiveness, efficiency and satisfaction of the system.
Section B: Professional cooperation among physicians with regard to the sharing of information and skills in the patient treatment with the implementation of the system.
Section C: Comments on the usefulness and relevance of FHIS in relation to the professional cooperation among physicians.

Please answer **ALL questions** by ticking (√) the appropriate box where applicable.

All data collected will be treated with strict confidence and used only for research purposes. Names will remain anonymous. Returned survey forms will be duly destroyed upon completion of the research project.

Thank you very much for participating in this research study.

Nawzat S. Ahmed
PhD Student
Metric No: WHA080031
E-mail: nawzats@uod.ac or nawzats@siswa.um.edu.my
Faculty of Computer Science and Information Technology
University of Malaya
50603 Kuala Lumpur
Malaysia

Please fill in your particulars below:

Date: ____

Name: _______________________________________

Hospital: _____________________________________

E-mail Address: _______________________________

Section A: System usability scale

Please check the box that reflects your immediate response to each statement. Don't think too long about each statement. Make sure you respond to every statement. If you don't know how to respond, simply check box "3."

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Section B: Professional cooperation among physicians

How do you rate the level of cooperation among physicians with regard to each of the following?

6. No Cooperation
7. Little Cooperation
8. Some Cooperation
9. Good Cooperation
10. Very Good Cooperation

1 No Cooperation	2 Little Cooperation	3 Some Cooperation	4 Good Cooperation	5 Very Good Cooperation

Please indicate your opinion by ticking (√) one box for each type of cooperation.

No	Type of Cooperation	1	2	3	4	5
1	Physicians sharing of skills in the same hospital					
2	Physicians sharing of skills in various hospitals in your town					
3	Physicians sharing of skills by means of a database for distributing information among them in your hospital					
4	Physicians sharing of skills through research and development activities among hospitals					
5	Physicians sharing of skills from different hospitals in order to improve their skills					
6	Physicians sharing of skills with regard to connecting healthcare information systems among hospitals in order to enhance the quality of healthcare services					
7	Cooperation among physicians with regard to design system for healthcare activities among hospitals					
8	Physicians sharing of skills among different hospitals in order to increase the use of human resources					
9	cooperation among physicians with regard to distributing a new activity happens in the system among them in real-time					

Section C: Comments on the usefulness and relevance of FHIS in relation to the professional cooperation among physicians.

Is FHIS a useful system for improving the cooperation among physicians?

If the answer is yes, what are the strong points of FHIS?

In your opinion, what are the weaknesses of FHIS? Give suggestions on how the utilization of FHIS used in the cooperation among physicians within the hospital environment can be further improved.

How does the FHIS improve the skills of physicians, please explain?

How does the FHIS help patient and healthcare services?

Thank You Very Much For Answering This Questionnaire

APPENDIX D

In-depth Interviews of Specialist Physicians for evaluation of the FHIS

A data display table of responses for each of the specialist physician in each hospital are shown below.

Source: Interview
Interviewee Code: Ev1
Hospital Name: Hospital A
Duration of interview: 39 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
It is very good system and easy to use. For us, we can get many benefits from the information and knowledge of this system.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
This system provides information more than 90%, which is meaning that to a considerable extent.
What do you expect from this system?
I expect from this system, and if you connect all cardiac centres of Kurdistan region or Iraq together, for example, will provide the huge benefits to their doctors. Means……means, if the cardiac centres in Kurdistan region or Iraq participate in international conference, it will participate as Kurdistan region or Iraq's country cardiac centres, as other countries (e.g. France, USA ...etc.) when they participated in any international conference, as I saw. By this system, we will have all real information about rare cases, any case and statistical in any centre. So that, we can do our research and participate in any conference by the name of region or country, instead of one centre, which is not acceptable.
Does it meet your expectations?
Yes of course, as I mentioned before, it meets our expectations in order to get many benefits for sharing our experience.
How do you compare the new system with the old system?
There is no system in our field in order to compare with this system. For us in Azadi hospital more than three years of work, we do on vision in a system which is meaning that there is no system. This is the first time of working in the real system.
What problems do you face if any, while using this system?
There is no problem during of work within this system and there is no difficulty of using this system just a couple of times you will know everything in this system. Only, we have one problem. It is the time factor due to our healthcare organization system in Iraq, especially in Kurdistan region allows us to work in many sectors, for example, in Government and private hospitals. Therefore, there is no enough time to work on like this system as the developed countries. Now, there is planning to do what I mentioned before from Ministry of health in Kurdistan region to allow doctors to work in Government or private hospitals in order to provide doctors with a more time for working on like these systems and providing better care to patients.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?
Response

In my opinion, this system very successful in the beginning and it is first time to apply this kind of system in our field. Moreover, the system will be updated during the work.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
Yes of course, the cooperation has improved not only among physicians in the same centre but also between different centres. For example, due to the availability of a cardiac centre in Sulaymaniyah now, It is more better if you connect Sulaymaniyah city as well instead of keeping it between Duhok and Erbil in the Kurdistan region.
Question (4): Please explain how skill can be shared?
The sharing of information and knowledge of physician's skills in the patient treatment is very good and successful as the system provided. This system provides integrated information about cardiac diseases, which are very important in our work.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
This system can improve the cooperation among physicians from zero to above 75% because of unavailability of any type of cooperation among physicians within same and between different hospitals. For instance, Some times we hear from our patients that there is a visitor doctor (expert in cardiologist) came to another hospital, for example, in Erbil; but we haven't any type of cooperation in order to know, connect, cooperate and share our experience with others. Therefore, this system is very important to improve the cooperation among us.
Question (6): Will system implementation have an impact on physician’s skills and healthcare services in the hospital?
Surly, this system will impact on our skills, especially in the patient treatment. It will affect at rates varying from a doctor to another.
Question (7): What are opinions about FHIS impact on the physician’s skills to provide better quality care and enhance healthcare services in the hospital?
In my opinion, this system updates and improves our knowledge, which leads to improve healthcare services by providing a good care to our patients.
Question (8): What do you think this system has brought to your work environment?
When this system has been applied by medical staff and management, it will enhance healthcare services and improve the cooperation among medical staff and provide a good care to patients in our hospital.

Source: Interview
Interviewee Code: Ev2
Hospital Name: Hospital A
Duration of interview: 16 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
During the work, I saw the system very easy and not difficult. Only it needs simple training in order to be familiar with this system.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
This system is providing information, as we need, to a considerable extent.
What do you expect from this system?
In general, the goal of this system is to connect all cardiac centres or hospitals in Iraq. Of course, this system is very good to exchange experiences of physicians among them. During of work on this system, we can improve our information, knowledge and work, and it can provide a competition area among physicians. Due to unavailability of the cooperation among physicians, especially in Iraq, this system will improve the cooperation among our physicians in the way of sharing of information and knowledge.
Does it meet your expectations?
In the beginning, this system is very good and acceptable; but we need more advance. In our live, we couldn't be expecting to apply like this system. As outside of the country like developed countries, they are using many good healthcare systems. We believed that it is impossible to reach what they reached; but starting with this system as a first step it could be reached.
How do you compare the new system with the old system?
We can't compare this new system with the old one because of there is no old system. For example, when a patient comes to Catheterization department to do PCI, new file number opens for a patient. Next time when he comes to do another PCI, another new file number will be opened for the same patient as a new one, which is meaning that one patient has multi file numbers. In this case, it is difficult to organize the information and find history of the patient. Also, we can't know anything about his previous operations that have been done. Therefore, I said there is no old system to compare with this a new system that can save all the patient history. In addition, we can find the patient information very easy and can get a good knowledge from other physicians by using this system.
What problems do you face if any, while using this system?
I couldn't use this system for many times. I was just used it for some times. During my work on this system, I couldn't find any problem and difficulty of the using. Maybe in the future we find some problems; but it could be solved.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?
Response

For answering this question, the system is very easy through the use; but using this system needs time to work on it in order to see the effective of this system.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
I believe that this system is the important thing in the improvement of cooperation among physicians with regards to the sharing of information and physician's skills in the patient treatment, as a knowledge. It may be for a long time of using this system could be brought many benefits for patients.
Question (4): Please explain how skill can be shared?
For us as cardiologist working in Cath's lab, it is important of this system to have videos and/or pictures of operations that have been done for patients beside the information about those operations. In the beginning, this system is very good for cooperation; but needs some updating in order to be more effective.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
This system is very important to provide knowledge of other physicians' work and to see all cases that have been done by other physicians, especially in the patient treatment and to encourage physicians to enhance their works. For example, I can use other physicians' ways, and they can use my way in the patient treatment if it was fond that it is the best way and so on. In addition, The kind of information and knowledge that provided by this system increase the communication among physicians and improve our experience through the acquisition of knowledge from multi-expert physicians.
Question (6): Will system implementation have an impact on physician’s skills and healthcare services in the hospital?
As I mentioned previously by the using this system, I could acquire new knowledge from expert physicians, who did some rare cases. Also, I can call them to explain how they did and to do some workshops about these rare cases. By this way, it will impact on the way of our work in the patient treatment.
Question (7): What are opinions about FHIS impact on the physician’s skills to provide better quality care and enhance healthcare services in the hospital?
Currently, due to unavailable of any type of cooperation among physicians within the hospital environment in our country, especially Kurdistan region, this system will improve the cooperation feature among physicians, which leads to enhance healthcare services by providing a good care to our patients.
Question (8): What do you think this system has brought to your work environment?
By using this system for a long time, it will organize the patient information, improve our knowledge in the patient treatment through providing a good cooperation among physicians and help us to do more researches in our field. In addition, it will enhance healthcare services by providing a better quality care to our patients.

Source: Interview
Interviewee Code: Ev3
Hospital Name: Hospital A
Duration of interview: 15 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
Really, the system is easy in the work. I encourage all doctors to work on it.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
The system has more benefit to our patients. It organizes patient information and provides us this information as we need, which is meaning to a considerable extent of providing information.
What do you expect from this system?
As I know, applying of this system for a long time needs to solve or to eliminate some obstacles. First of all, records of the patient information in admission unit, then send to other units. Second, decrease the number of patient visitors, because of the huge numbers of visitors now, we can't monitor or organize these numbers of patients in order to consider their cases and record their information. So that, it is difficult for us to do both. Therefore, we need other persons to do data entry at the time of work. As I see, this system is very good for doctors and patients during our work. We can get many benefits, such as improving our knowledge and providing us more information for researches.
Does it meet your expectations?
Certainly, the system is a nice thing. For the first time, I notice such a system. Moreover, this system needs more updating in the future during the work in order to meet all our desires.
How do you compare the new system with the old system?
In our hospital, there is no computer-based system. All our work is paper-based, and we write the physical examination and diagnosis on the pace of paper. Therefore, this new system is better than the old system, and it is very helpful for doctors.
What problems do you face if any, while using this system?
During the work, I didn't face any problem because of the system is very nice, and very easy for data entry and searching. In this system, the problem is only in the accuracy of the introduction of information and the reliability of information that have entered by a certain person.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?
Response
Retrieval of information and physicians' skills in the patient treatment is the main goal of this system. Therefore, the extent of retrieval of information is very good and successful, in my opinion.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
Definitely, inserting the information of all our patients, especially rare cases, from different departments and/or hospitals into the system, it will improve the cooperation among doctors much better.
Question (4): Please explain how skill can be shared?

For sharing of physicians' skills in the patient treatment, definitely I agree with this new system. The kind of information that the system provided, it is important for sharing our skills as knowledge. In addition, it is improved and develops our work.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
By using this system, it is the best way of cooperation among physicians within same and different hospitals. Moreover, the system is providing important information and knowledge in the patient treatment in order to know how other colleagues are doing their works and to acquire new knowledge from them. Therefore, the system provides a good type of the cooperation.
Question (6): Will system implementation have an impact on physician’s skills and healthcare services in the hospital?
Of course, this system has an impact on our skills, especially in the patient treatment. I can see all cases have done by our hospital and others, and types of diagnosis and therapeutics. Also, I can know the type of complications that happen and why. In addition, this system provides information that could be important for our researches due to a good and acceptable research should have information from different centres not only from one centre. Moreover, and certainly, this system is good not only for doctors but also for patients.
Question (7): What are opinions about FHIS impact on the physician’s skills to provide better quality care and enhance healthcare services in the hospital?
Certainly, the system has good results and services not only for doctors but also for patients, as I mentioned previously. In my opinion, this system needs more support, such as financial, persons for data entry in order to keep going of this system in the work as a main key for a healthcare information system in our country for connecting and sharing information among different hospitals.
Question (8): What do you think this system has brought to your work environment?
As I see, this system is better for statistical information and development of scientific research in our hospital. In addition, it is improving the cooperation among physicians and providing a good care for patients. The system will be successfully updated in the future.

Source: Interview
Interviewee Code: Ev4
Hospital Name: Hospital A
Duration of interview: 15 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
Definitely, the system is very easy and so friendly. There is no complexity in the system, especially the icons used on the web pages are clear, and anybody can use and know what meaning these icons. In addition, you are focusing on the icons have related to our work.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
This system provides us the information to a very wide range because it contains a lot of information. We can get more details of doctors and patients instead of our old system.
What do you expect from this system?
I expect two things useful, First, as a doctor or researcher I can follow up the statistical information of our centre and others. I can get these information very easy in a short time from the system as charts and/or figures because of the time factor is important for us, as well as we can use these information in our work or research. Second, we can acquire the more experience from others due to there is a connection among different centres with regards to the sharing of information and knowledge. In addition, the area of research and cooperation will be increased due to the availability of this connection among different centres instead of a single centre.
Does it meet your expectations?
Of course yes, this system is practical and meets my desires more than what I expected.
How do you compare the new system with the old system?
On the contrary, there is no type of comparison between the old and new system because of the old system is paper-based. All the patient information keeps in a cupboard or placed on the shelf. More times, We lose some of these information. It is very difficult to manage these information over time. Moreover, by using the new system can keep, manage and organize these information more easily.
What problems do you face if any, while using this system?
I haven't faced any problem during the work due to the system was easy.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?
Response
The system is very successful in the retrieval of information with more details in a short time. Furthermore, this system provides information, as I need, from different fields.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
Certainly, one hundred percent will be increased the cooperation between doctors and participate in experiences, especially when all healthcare centres have connected by this system.
Question (4): Please explain how skill can be shared?

The type of cooperation that provided by this system is very good and acceptable; but if we go more in-depth details, this system needs more updating over time. For example, for more details about operation information this system needs to have such as operation's pictures and/or videos, questions and answers, video conference and discussion way among surgeons.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
Of course, this system brings the improvement in cooperation among doctors within the hospital environment; because, you can see the daily activities or events from different healthcare centres during minutes. This kind of the communication supports you with the information as you life with doctors in those centres. Definitely, it provides more communication and cooperation among physicians, especially cardiac physicians.
Question (6): Will system implementation have an impact on physician's skills and healthcare services in the hospital?
Certainly, services provided by this system is reflected to the patient more; because the existing information on the activities of doctors and patients will certainly help us in our research to develop information, to benefit from the experiences of others, to correct our previous mistakes in the patient treatment, to improve our expertise and to better service to the patient.
Question (7): What are opinions about FHIS impact on the physician's skills to provide better quality care and enhance healthcare services in the hospital?
As I mentioned previously, this system has benefited not only for patients but also for doctors. It provides the cooperation among physicians in order to share their experiences in the patient treatment and provision a good quality of care to patients.
Question (8): What do you think this system has brought to your work environment?
In general, this system is very good and has two main benefits the first for patient and the second for doctor. In addition, I advise all of our physicians in the centre to use this system permanently.

Source: Interview
Interviewee Code: Ev5
Hospital Name: Hospital A
Duration of interview: 25 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
For me, this system was very easy during of work. It just needed 5 minutes to learn how to use it.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
In my opinion, it provides information to a considerable extent.
What do you expect from this system?
I expect that the system is very successful. Why it is successful? it is successful for three things. First, the system is very important for a patient. For example, when the patient comes to see a doctor and have a chest pain. The doctor will try to find and diagnose the patient illness through the doctor's experience and/or sending the patient to do some investigations, such as (EHO, ECG, Exercise, Catheter,...ect.). Before applying this system, our system was paper-based. Furthermore, our patient can see many doctors of our centre at different times, and each one of the doctors has own investigations, diagnosis and therapeutics for the patient. Therefore, sometimes the patient will lose list of medicine and/or reports of investigations that has been done for him/her. Further, it is very difficult for the doctor to find and diagnosis the patient illness without reports and historical information of the patient. In addition, I saw some of our patients had more than one catheter in order to diagnose his/her illness from different doctors which is meaning that it is very dangerous for the patient to do all of these catheters. Second, This system is very important for the doctors. For example, we can see the historical information of our patients, the information of other hospitals, the knowledge acquirement from other doctors within the hospital environment. Finally, it is very benefited for the hospital to have like this system. For instance,this hospital is government hospital, which is meaning that many things are free for the patient. So that, when the patient information has stored in the system the patient can get fewer investigations. is no repetition of investigations for the patient which leads more benefit to the process and finance of hospital.
Does it meet your expectations?
Yes, this system has more my expectations. I saw many new things in this system never seen before.
How do you compare the new system with the old system?
Certainly, we haven't any system in order to compare with this new one. Currently, the moste work of our old system is paper-based. For example, when a patient comes to see me in order to get treatment. After I finish, the patient will discharge from the hospital with taking everything has been done for him/her, which is meaning that the patient will take every copy of investigations' reports. Therefore, if the patient doesn't bring these reports and/or medicines have done for him/her in the next visiting, I have nothing to see and do. I will do with him/her as a new patient. It is a big problem we have now. In addition, there are no documents showing any of our mistakes at work. For instance, sometimes the patient will get wrong diagnosis and/or therapeutic by us which leads to kill him/her. By using this new system, everything will be right and our mistakes will be documented and could be less. Also, if we can't diagnose the patient illness, we send or discuss the patient information with another doctor in order to get help for providing a right diagnosis and treatment of the patient. This system creates the type of cooperation among physicians.
What problems do you face if any, while using this system?
I didn't face any problems.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?

Response
According to my expectations, this system is very helpful and successful to provide much information related to our work in order to improve the cooperation among doctors and enhance our skills in the patient treatment for ever. For instance, when I see a patient, I write my notes on the patient case. When this patient goes to see another doctor, the doctor can see the historical information and also add more notes. By this way, we can provide a good care for our patients. In addition, if there is genius doctor in Erbil. I can see everything he did for the patient and acquire new knowledge from his experience and so on.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
Yes of course, By using this system the level of cooperation among physicians can be improved much better. This system could provide a new information and knowledge related to our work. Furthermore, we can know and see many other doctors never heard and seen before.
Question (4): Please explain how skill can be shared?
The good type of the sharing of physician's skills in the patient treatment is provided by this new system. For example, I can see the information of doctors and skills of doctors as a knowledge, and acquire a new knowledge. In addition, when I get difficult to diagnose a patient's case, I can search on the system , call or contact with a good doctor in order to get more help to diagnose this case.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
I predict that this system can improve the cooperation among doctors and enhance our skills to the good extent.
Question (6): Will system implementation have an impact on physician’s skills and healthcare services in the hospital?
This system is a good system for providing the information in order to improve our skills in the patient treatment. For example, in the first I can see most of the patients when they come to our centre. Therefore, I can see their historical information and see all investigations, diagnosis and therapeutics have done by our expert doctors. This work can show me the new approach of how to diagnose and treat the patient. In addition, this system enhances the healthcare services by helping and providing good services for patients.
Question (7): What are opinions about FHIS impact on the physician’s skills to provide better quality care and enhance healthcare services in the hospital?
In my opinion, again, this system improves our skills in the patient treatment with regards to the sharing of information and knowledge. Also, it provides a good quality of care for patients. For instance, the system reduces the time consuming of the patient diagnosis because of the availability of the historical information for a patient. Next, it reduces the harm to the patient due to the repetition of investigation processes in the old system. Finally, this system decreases the effort of medical staff during the daily work.
Question (8): What do you think this system has brought to your work environment?
This system has brought many things. First, the system brings progress to our centre and makes us to feel that we can reach our neighboring countries such as Europ countries because we are weak in the technology information. Second, it brings many benefits for our patients and doctors. For instance, in the previous years if somebody told you someone has heart disease you will think he is an old person; but current this disease available among young people (i.e. 25-30 ages). Therefore, this system can help us to follow up these cases and find why it happened as well as we can see the statistical information of these cases how they increased by months and/or years. Next, like this system reduces the load of hospital to provide services. Finally, it increases the cooperation among physicians within the hospital environment due to the absence of this type of cooperation in the previous system.

Source: Interview
Interviewee Code: Ev6
Hospital Name: Hospital B
Duration of interview: 15 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
The system was easy in use during the work.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
The system provides a lot of information to the considerable extent. In addition, the idea of this system is a new and systematic.
What do you expect from this system?
Application of this system successful and effective, and has great results. In addition, this dream of any hospital that has such a system, especially it improves the experience of doctors and provides better services for patients.
Does it meet your expectations?
Of course yes, It meets my expectations as I need and more.
How do you compare the new system with the old system?
This new system is more updated than old one that we have.
What problems do you face if any, while using this system?
I did not face any problems. Everything was easy during the search and work.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?
Response
This system is more successful in the retrieval of information to the hundred percent. Applying of the system all physicians can work together and can organize the hospital processes. Also, it provides a good information for researches.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
Of course, this system improves the cooperation among our doctors as well as the doctors could work in the right and scientific way instead of previously. For example, it reduces the mistakes of doctors. Next, the doctor can provide a good quality care for patients.
Question (4): Please explain how skill can be shared?
I agree with the way of sharing of information have provided by this system to 95%. It provides more information that we need. More efforts have been taken in order to do this system for providing a good information and improving our knowledge by sharing our skills in the patient treatment among us.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
This system has created a best cooperation among physicians because it is easy to be done. It just needs the internet to be connected with other hospitals.

Question (6): Will system implementation have an impact on physician's skills and healthcare services in the hospital?
This system certainly has a significant effect on improving the experience of doctors and enhancing healthcare services provided to the patient. In addition, it is possible of the system to add other things. For instance, the management system of store such as medical equipments, medicines in order to show the shortage of medical equipment and medicines. Next, we can manage our medical staff and see the rate of shortage.
Question (7): What are opinions about FHIS impact on the physician's skills to provide better quality care and enhance healthcare services in the hospital?
In my opinion, of this question is that this system is very useful for the patient because it is possible for more than a doctor to participate in the treatment of the patient. Further, there is participated in the skills of doctors to provide the best treatment for a particular patient needs more consultations.
Question (8): What do you think this system has brought to your work environment?
This system has brought many things. For instance, it provides us with a good information and knowledge. Next, it brings progress to our hospital. Finally, the system is new in our country it has never seen before.

Source: Interview
Interviewee Code: Ev7
Hospital Name: Hospital B
Duration of interview: 33 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
The system is easy and can be controlled through practice and research on the information; but there is a problem in our centre. The problem is there is a difficulty in the introduction of all the tests related to the patient by our medical staff because some of them do not enter any information; but this problem belongs to the hospital administration not this system.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
This system provides information to the extent of good and advanced, especially when the commitment from all enter the information in full and on time.
What do you expect from this system?
The system will benefit for the doctor and patient as well as conducting research in the future is going. For example, now in the old system we have graduate students are doing researches; but it is very difficult for them to find information, especial echo investigations. Therefore, they try to contact with patients; however, it is very difficult to find most of these patients. For that reason, this system solves this problem, and it is easy for our students to get more information in a short time. Next, assess the work of a doctor and the doctor's diagnosis. In other words, at first sight the doctor can diagnose the patient's case and then see the success of this diagnosis.
Does it meet your expectations?
Yes, I want such a system, and I am the first supporter; but there are some difficulties in dealing with this system. First, there is a lack of a sufficient number of the staff who assist the doctor in the introduction of all information as well as the momentum in the number of patients visiting a day. Second, the doctor outside the hospital sends a patient directly to units other than the consultation unit in order to see the patient's case. For example, the doctor sends a patient to the operating room directly from outside the hospital without reviewing by other units in order to insert the patient information in the system. Therefore, it is difficult to control on these cases. In addition, we need from the hospital management to put the process of introduction of patients to the hospital in an orderly fashion, such as this system, not randomly as we have now.
How do you compare the new system with the old system?
Method of introduction of information to the system is almost similar to the system that we have, but the new system has some characterized from the old system. First, it is connected to the global network (i.e. the Internet);); but our old system just has the local network. Second, in our old system there are some problems such as the network is not good and there are many viruses, but with this new system, we have not faced like these problems. Next, the information in the new system which is more mature than the old system. In addition, the new system is distinguished from the old system that there are coherence and cooperation among different hospitals. Therefore, we can observe all the activities which they carry out the doctors in the rest of the hospitals associated with this system. Further, this will generate some kind of acquaintance and cooperation between doctors within different hospitals at the region, country and/or globally if associated with hospitals outside the country.
What problems do you face if any, while using this system?
This system is easier than the previous one. In addition, it can solve most of the problems that we have. For example, we can get rid of the viruses' problem as I mentioned previously.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?
Response

This system well in the information retrieval and in the exchange of experiences between doctors within the hospital environment. it helps to improve the experiences of doctors. the doctors can also participate in the treatment of patients, because in some cases, we send our patients out of the country for treatment, particularly to centres who are linked to this system. The system is also successful, in my opinion, and if we see there is no enough information can be added again in the future, such as other observations about the patient in another field. For example, the patient needs special care or follow-up, especially in the treatment if it happened to him other complications if it does not exist.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
This system is good in the exchanging of views, experiences. Also, it is possible to contact with the concerned doctor because this system also provides information about the doctor. Through these information, I can call or send email to the concerned doctor for consultation on cases of patients who treated by him in order to see these cases have done properly or there is a difference of opinion. In addition, if I have similar cases, how could it treated ...etc.? Further, This work is to increase cooperation between doctors and possible to do joint research in the future, which provides the statistical information and knowledge among medical centres associated with each other.
Question (4): Please explain how skill can be shared?
As provided by this system is very useful in the sharing of information because of the dissemination of science and experience of doctors is the most important thing now. For example, sometimes we do a search on the researches that have been done by the doctors in the international journals in order to devise a new information and convenient in the treatment of our patients.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
This system provides well cooperation among doctors. Furthermore, the doctors can get visits with each other and can share their experiences or patients. Sometimes a doctor can know the department and time that work another doctor in another hospital. They can also gain experience of doctors to treat difficult cases that have been treated by other doctors. Further, by using this system has benefited for patients. For example, if the patient lives in another city and have a difficult case, the doctor in that city can contact with us in order to have information for the patient treatment instead of sending the patient.
Question (6): Will system implementation have an impact on physician’s skills and healthcare services in the hospital?
Yes, the implementation of system has a significant effect on increasing the cooperation among doctors, as I mentioned before, and increasing healthcare services in the hospital. For instance, any hospital which does not have good statistical information and information about patients is minus in the work. This work which leads to be unable to follow up the patient and difficult to get all information about the patient.
Question (7): What are opinions about FHIS impact on the physician’s skills to provide better quality care and enhance healthcare services in the hospital?
Of course, this system provides better quality care for patients. For example, there are some patient admits to the hospital three to four times per year for different problems. Therefore, it is very difficult to follow up these kinds of the patients when the information recorded on papers. Further, today I saw one of my patients I already gave him a medication in the previous visiting; but the pharmacist gave him the wrong medication, I didn't write it and there is no record to know or show which medication I wrote. For that reason, the patient's case became fare worse. Therefore, by using like this system, we can solve our previous problems and provide a good care to the patients.
Question (8): What do you think this system has brought to your work environment?
Application of the system develops the work, increases the attention of doctors with patients and becomes a diagnosis of the patient in a scientific, well and error-free as possible. This system has the registration of all services provided to the patient. In addition, It is easy to find the patient information and which physician treated this patient and how they were treated. Finally, this system provides cooperation between doctors, whether inside or outside the hospital.

Source: Interview
Interviewee Code: Ev8
Hospital Name: Hospital B
Duration of interview: 22 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
The system is easy during the work and applicable. It has benefited to the patient, physician and researcher. Furthermore, the system has benefited for the graduate researches; but we have a problem or difficulty with the introduction of all data on the patient in the system because of the time factor, so it must be accompanied with a specialist doctor another person who has experience or competence of the medical domain in order to enter information into the system correctly and on time.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
This system benefits me well, to a considerable extent. It is interested in documenting the patient information and doing the research in future.
What do you expect from this system?
The system is also useful in the acquisition of knowledge and information from other centres associated with this system. For example, I can see the mortality rate from another centre such as Dohuk. In addition, this rate was bad, then I can see the problem and contact them in order to solve this problem. Next, through this system, I can see all the rare cases that have occurred at the level of region or country and distinction whichever is rare and not. I can call the doctor to tell him your case that you have treated is not a rare case, but already processed by our centre, etc. By this way, the system improves the cooperation among physicians in the exchange of experiences.
Does it meet your expectations?
This system is satisfactory. There is a saying a distance of thousand miles starts as the first step. This system is good now; but in the future possible to add other things that do not exist or forgotten, or needed by the doctor or centre. Maybe, there is much information we need for our research but still not provided by this system. For example, We have Helicobacter test; however, nobody is used it in order to enter the results in the system. Therefore, we need to use this test, and the system needs to have a field for saving results of this test.
How do you compare the new system with the old system?
In order to compare this system with the former, the new system is an excellent in the providing more information. While, the old system has failed miserably because it was not supported by anybody. The other reason is a specialist physician has carried a lot of work and seen a lot of patients. At the beginning of the work was a random management of patients. Therefore, we can't control on the organization of patients. While, there are now aware of the doctor and patient on the organization. In addition, the work on the new system can be much better.
What problems do you face if any, while using this system?
I did not see any problem during the work. The system was easy, efficient, and informative. Maybe in the future, we could face problems; but it will possible to solve these problems and add things if they do not exist such as the analysis or examination, etc.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?
Response

This system gives a good information from different centres in order to benefit from it in the process of trainings, researches and dissemination of such researches in the international medical journals. In addition, we can see statistical information from other centres in order to assess these centres are good or not. Furthermore, we can discuss on the cases that we have in our region instead of cases outside our country. For instance, I can show these cases that have done by our centre or others for our students in order to provide them with a good knowledge.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
In my opinion, using this system is increasing cooperation among doctors, because as long as there are cooperation and competition across the internet, instead of dialogue and competition with each other through the oral communication, due to such the communication leads to exchange incorrect information and experiences among doctors. For example, one of the doctors says I dealt with 200 cases, but he only treated 20 cases so the system provides the correct information. In addition, the system generates a reliable and effective information rather than the oral communication.
Question (4): Please explain how skill can be shared?
The information that provided by this system is a good type of the sharing of skills among doctors. Therefore, this system provides the trust between doctors and is useful in the education. I can share my experience with others and get other doctors' experiences.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
As I mentioned earlier, as long as the doctors are dealing with each other in the exchange of information via the Internet. It shall be there is confidence in the cooperation. For example, when I meet a doctor at a conference then he says: he has treated 300 cases and there is no mortality. After that, when I see the system, he already had only 150 cases and there is high mortality, which is meaning that he did not say the truth. So that, the system provides the truthfulness of the cooperation among doctors much better. In addition, this system is better than conference because you know what others do, and they know what to do you. The system is open. Next, I hope that the information of this system are in good hands.
Question (6): Will system implementation have an impact on physician’s skills and healthcare services in the hospital?
Definitely, implementation of this system impacts on our experience and improves the experience of who has a lack of experience. It shows error in the work of doctor if there. Also, I can check the cases that I have done which are rare cases or not from other doctors in the different centres. For example, a certain period before I made a one rare case. When I tried to publish this case, the publisher asked me how many of these cases you have in your country, I answered that question: I don't know; but using this system it was possible to know. I can see the rate of successful of each operation. In addition, other doctors can get many benefits from the system after me. It increases the level of learning or teaching of new doctors. I can get a case report easier than go to other centres in order to get information to do my research. So that, It improves the knowledge of physicians. Further, through this system, I can see my patient information and follow up his case quickly as well as I can see all the medications that have been given to him by us. Therefore, It provides good services for patients.
Question (7): What are opinions about FHIS impact on the physician’s skills to provide better quality care and enhance healthcare services in the hospital?
In my opinion, this system has benefited for the physician and patient, why? Sometimes, I give the medication to the patient until the next visit. Next, in some cases, the patient forgets to take medication that I wrote for him to take after the operation. For example, the patient visited me a while ago and he did not take aspirin for a one year. In addition, why he didn't take it. The answer was "no one advised me to take the aspirin". Therefore, I did not know who is wrong the doctor or patient, because we do not have any document to a prove that; but using this system we can a prove that. In addition, this system improves our work by the sharing of information and physician's skills in the patient treatment among physicians within same and different hospitals.
Question (8): What do you think this system has brought to your work environment?
The system is very important and beneficial regarding the science, teaching, research and information. These four points that I mentioned previously very important for each healthcare organization in order to show the functions for each healthcare centre. In addition, this system provides a good way of cooperation and sharing of information among physicians in order to enhance the outcomes of the centre.

Source: Interview
Interviewee Code: Ev9
Hospital Name: Hospital B
Duration of interview: 10 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
The system is easy to handle, but it needs some time to learn all the details found in this system.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
The system provides us with good information to a good extent if it applied fully and correctly.
What do you expect from this system?
Applying of this system can solve some big problems that we have in the Kurdistan region. First, there is no protocol of controlling on the patient record in this region. Second, the system in healthcare organization that we have is very old and unsatisfactory for us and patients. Therefore, this new system can help us to have guided of the patient information. In addition, it can organize and enhance our work in order to give our patients same treatment that has done successfully. Also, a doctor who has some mistakes in his/her work can be solved through the acquisition of knowledge from other doctors. Further, the doctor must work more accuracy in a scientific way.
Does it meet your expectations?
Yes, this system provides what I needed, but needs some updates in order to provide more information. The reason is the application of any system initially faces some difficulties and problems; but in the end, it becomes a good system and acceptable.
How do you compare the new system with the old system?
I can not describe the comparison between the old and new system. The reason is unavailable of the old system. Also, in our work, all notes of the patient treatment are recorded on the paper only.
What problems do you face if any, while using this system?
There are no problems by using this system; but only we have a problem in the internet service of our centre. Sometimes, this service becomes very slow. Therefore, we can't login to the system.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?
Response
Yes, the system provides the information well. This system helps doctors to improve their work and to create a spirit of competition among them.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
Yes, certainly this work improves the level of cooperation among doctors, particularly in the sharing of information, knowledge and statistical information that provided by this system.
Question (4): Please explain how skill can be shared?
As I mentioned before, doctors can get many benefits of the sharing of information and knowledge. They can use these information in their daily work and research. For example, The statistical information can help us to know all the cases that we have in the Kurdistan region and can prepare researches very easy. In addition, the doctors can gain the experience from each other.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
This system certainly has a significant effect on the cooperation feature between doctors within the hospital and others.
Question (6): Will system implementation have an impact on physician's skills and healthcare services in the hospital?

Yes, this system has an effect on the skills of doctor and healthcare services. For example, I'm talking about myself, before the implementation of this system when the patient comes to see me. I do physical examination then I don't record the information of this examination on the paper or system in a computer. For that reason, soon I will forget what I've done for this patient. I will try to do from the beginning as a new patient. While storing all information concerning my work around the patient in the system will help me to provide better service to the patient. Also, it will help me to improve my skills through the exchange of information and knowledge among doctors.
Question (7): What are opinions about FHIS impact on the physician's skills to provide better quality care and enhance healthcare services in the hospital?
My opinion in this regard is that the world is heading towards progress in health systems in order to provide better services to the patient. Therefore, the application of this new system should identify the doctor what he does and what he did. In addition, this system saves time and labor to the doctor and patient. Also, it provides a key reference for the doctor to know the status of the patient and provide better service to the patient.
Question (8): What do you think this system has brought to your work environment?
I feel now that I have a system. I can work on it, and I feel that our health has a good system in order to provide quality services to patients. For example, I attended several international conferences and visited other health centres outside the country as a visitor. I did not notice the great difference in our experience of work from others outside; but they have a structured system, and we have a random system. So that, If such a system applied in most of our health centres will make the work more progress from the outside of the country.

Source: Interview
Interviewee Code: Ev10
Hospital Name: Hospital B
Duration of interview: 10 minutes

Question (1): I would like to start by asking you about the Fractal-based Healthcare Information System (FHIS) regarding the record keeping/maintaining and the information navigating that you are need to do as part of your job?
Prompts: Is the new system easy to use during your work?
Response
I imagine this system is easy and well in our work. I wish from all hospitals to accept work on this system because it provides the field to participate in the information and expertise among physicians. Nothing will be hidden everything will be clear in this point. It is a good system.
To what extent is the new system able to provide you with the information you need (to no or little extent; to some extent; or to considerable extent)?
This system gives me a lot of information successfully (i.e. to a considerable extent), because so far does not have a system in the region of Kurdistan in order to store, organize, and analyze the patient information as this system does.
What do you expect from this system?
Certainly, the application of the system brings an evolution and a work in progress. In the future, this system can be updated as possible to fit our requirements.
Does it meet your expectations?
Yes, this system corresponds to what I needed well.
How do you compare the new system with the old system?
I cannot compare because of a lack of old system in order to compare with this new system.
What problems do you face if any, while using this system?
I have not encountered any problem during my work in this system.
Question (2): What is the extent of successful retrieval of information and physicians skills in the patient treatment within the hospital environment?
Response
Retrieval of the information in this system is successful and large. For example, I out information about the schedules of doctors and their experience as well as all patient information.
Question (3): Are the levels of cooperation among physicians improved with regard to the sharing of information and skills in the patient treatment with the implementation of the system?
Certainly, the idea in this system increases the cooperation between doctors in terms of the exchange of information and skills in the patient treatment.
Question (4): Please explain how skill can be shared?
I am agreed with the idea of this system for sharing of doctors' skills among each other. This will lead to improve our experience in the patient treatment which leads to provide a good care.
Question (5): To what extent can FHIS improve the cooperation among physicians within the hospital environment?
There are many things in this system through which we can see and evaluate the work of other doctors. In addition, the sharing of information leads to an increase in cooperation among doctors in the hospital environment.
Question (6): Will system implementation have an impact on physician's skills and healthcare services in the hospital?
Certainly the information available in this system affect on our experience in the patient treatment because the system publishes my work between doctors and I can see the work of other doctors. By this way, this work provides the information and knowledge so that it is for doctors to gain experience of

others and this reflects a positive influence on health services provided by the centre for patients.
Question (7): What are opinions about FHIS impact on the physician's skills to provide better quality care and enhance healthcare services in the hospital?
In addition to what I mentioned earlier, this system was storing the patient information permanently. So that, a doctor can reviews this information and also facilitates the follow-up process and the addition of new information of the patient, if any.
Question (8): What do you think this system has brought to your work environment?
In general, this system first organizes the work, secondly improves the cooperation between doctors and improves the experiences of doctors, as well as enhances healthcare services.

APPENDIX E

Official letter approval

Through a written letter and personal visits, the researcher informed the health directors and hospital managers about the upcoming study. Then, official permission was obtained from the Research Ethics Committee of Health, the health directors and the hospital managers before gathering any information as shown in this APPENDIX.

UNIVERSITY OF MALAYA
KUALA LUMPUR
Producing Leaders Since 1905

يونيبرسيتي ملايا

To Whom It May Concern

This is to confirm that the student below is a registered fulltime PhD student in the Faculty of Computer Science and Information Technology at University Malaya. As part of the PhD program requirement, the student needs to do a data collection in an organization for the research purposes. The student detail is as follows:

Name:	Matric No:
Nawzat S Ahmed	WHA080031

The student is interested to conduct his research study in your organization. This study is solely for academic purposes. As such, please provide him with the necessary assistance. Your kind cooperation is highly appreciated.

Yours faithfully,

Dr Norizan Mohd Yasin
Senior Lecturer
Dept. of Information Systems
Faculty of Computer Science and Information Technology
University Malaya

MS ISO 9001: 2000 REG. NO. AR 2760

Faculty of Computer Science & Information Technology,
University of Malaya, 50603 Kuala Lumpur, Malaysia
Tel: (603) 79676300 / (603) 79676301 • Fax: (603) 79579249 / (603) 79676339
http://www.fsktm.um.edu.my

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Kurdistan Regional Government-Iraq

Ministry of Higher Education & Scientific Research
Duhok University
College of Medicine

Ministry of Health
Directorate General of Health- Duhok Governorate

Approval Form on Scientific Research by Research Ethics Committee

After reviewing the study submitted by Mr. **Nawzat S. Ahmed**.....on **6 / 11/ 09** /

titled..............**Real-Time Planning and Control Agent-Based Research and Development for Fractal Hospital**

We in the research ethics committee decided to

1. Accept the study without changes
2. Accept the study after taking in consideration the attached notes
3. Refuse the study for the following reasons:

1. ***The Ethics committee after reviewing the methodology of the research has come to a conclusion that it poses no risk neither to the people involved nor the health facilities in which the study will be conducted. On the contrary, it will have a positive impact on health facilities provision of health care***
2. ***A formal consent of health authorities has been obtained prior to study conduction.***
3. ***A formal consent of the interviewees has been obtained prior to start of the interviews***
4. ***A presentation about the research has been delivered to brief the health decision makers and the relevant personnel about the research did attended.***

Committee Chairman

Prof. Dr. Samim AL-Dabbagh

Member

Dr. Abdullah Jasem Rajab
CME-Director.

Member

Dr. Qasim Hasso
Ass. prof. Duhok College of Medicine

Member

Dr. Khalid Nawaf
Lecturer. Duhok College of Medicine

Member

Pharmacist. Bahjat Saeed

12/11/2009

Kurdistan Regional Government/Iraq
Ministry of Health

Directorate General of Health -Duhok Governorate
Number : 16501
Date : 16 , Sep , 2009

To : **Dr.Norizan Mohd Yasin**
Department of information system
Faculty of computer science and information technology
UNIVERSITY OF MALAYA

We hereby certify as director general of health (Duhok directorate general of health –Iraq Kurdistan) that our institutes of health are in real need for such academic researches and that our organization would provide the necessary information .
We are glad to help and support this student

Name:	Matric No:	Passport No.:
Nawzat S Ahmed	WHA080031	G2023055

Dr. Abdullah Saeed A.
DG/ DGOH /DHK

Directory of Health
Duhok
Director General Office

Email: office@duhokhealth.org
Duhok_doh2005@yahoo.com
Website: - www.duhokhealth.org
Phone No. +964 62 7244601
+964 62 7623660

KURDISTAN REGION –NORTHERN IRAQ
DIRECTORATE OF HEALTH -DOHUK
AZADI GENERAL TEACHING HOSPITAL

Date: ***25th November, 2009***

To: whom It may concern

We certify that PhD student **Nawzat S. Ahmed** collected data from our hospital. He has made the interviews with our physicians in the heart diseases unit during the October and the November in order to accomplish his project. We supported him with the required information.

Azadi General Teaching Hospital
DOH-Duhok
Director Office

Manager

Shakir Saleem Balindi
Azadi Teaching Hospital
Duhok / North Iraq
www.duhokhealth.org
009647504820851
25/11/2009

EMC

سەنتەری چارەسەری فریاگوزاری

Emergency Management Center

نەخۆشخانەی پسپۆری نەشتەرگەری

No:1688 Date:18/11/2009

To: Whom It may Concern

This is to certify that PhD student **Nawzat S. Ahmed (Matric No: WHA080031)** has collected all the information at our hospital that is related to his research purposes. The researcher was very cooperative to follow all the instructions and the procedures followed at the hospital. In order to assist him to accomplish his project we supported him with the required valuable information.

Best Regards…

EMC
Admin

Dr.Kamil Namiq Ahmad
Hospital Director

Tel:+9647504936371
Email:dr kamil 1950@yahoo.com

www.emc-hospitals.org
info@emc-hospitals.org

حکومەتا هەرێما کوردستانا / عێـــراق
وەزارەتـــــا ساخلـــــەمی
رێڤه بەریا گشتی یا ساخلەمیی ل پارێزگەها دهوکێ
سەنتەری ئازادی یێ نشتەرگەری ونەخوشیێن دلی

حكومة إقليم كوردستان - العراق
وزارة الصحـــــة
المديرية العامة لصحة محافظة دهوك
مركز أزادي للجراحة و أمراض القلب

ژمارە :139
رێکەفتی :2012/7/9
رێکەفتی :

To Whom It May Concern

We hereby certify that the PhD student Nawzat S. Ahmed (Passport No. G2023055) applied his system, named Fractal-based Healthcare Information System (FHIS), in our hospital to improve cooperation among physicians. This system is brought many benefits, such as improving physician skills in the patient treatment, providing patients with a good care and enhancing healthcare services. In order to fulfill research requirement, our hospital is tested FHIS system in April 2012 and continuous to evaluate outcomes of this system.

Sincerely,

Dr. Ashur Yohanna Izac
Cardiac Center Director

Azadi Heart Center / Duhok

Nakhoshkhana Road : 8 | جادا نەخوشخانێ 8

1	0	1	4

A	M

Duhok | دهوك

م	أ

1	0	1	4

EMC

سەنتەری چارەسەری فریاگوزاری

Emergency Management Center

نەخۆشخانەی پسپۆری نەشتەرگەری-سەنتەری دڵ

No:548 Date:12/5/2012

To: Whom It may Concern

This is to confirm that the PhD student Nawzat S. Ahmed (Passport No. G2023055) was tested his system under the name of Fractal-based Healthcare Information System (FHIS), in our hospital. This system will be applied for six months in order to see the effective of this system in the cooperation among physicians with regard to the sharing of information and skills in the patient treatment in our hospital and others. In order to assist the researcher for fulfilling his research requirements, our hospital is ready to support him with the required valuable information to evaluate the system.

Best Regards…

Dr.Kamil Namiq Ahmad
Hospital Director

Tel:+9647504936371
E-mail drkamil1950@yahoo.com

www.emc-hospitals.org
info@emc-hospitals.org

APPENDIX F

Reports of cardiac centre

The following are reports of patients released by each unit in two cardiac centres.

Kurdistan Regional Government-Iraq
Ministry of Health
DOH – Duhok
Azadi General Teaching Hospital

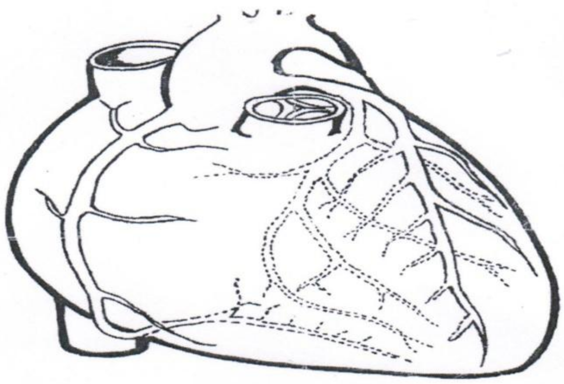
Duhok Heart Center

حکومەتا هەرێما کوردستانێ-عیراق
وەزارەتا ساخلەمیێ
رێڤەبەریا ساخلەمیا پارێزگەها دهوکێ
نەخوشخانا ئازادی یا گشتی یا فێرکرنێ

ژمارا قەستەرێ : 2949
نوژداریێ چارەسەر : د. محمد مطر
مێـــژوو:- 2009-11-22

ناڤێ نەخوشی:
ژینێ نەخوشی:
ژمارا سەرژمێریاری:531294

Technician	***Radiologist***	***Nurse***
Fuaad Karem	**Zana Muhammed**	**Muthana Ghaze**
Majeed Rasheed	**Abdullstar Mustafa**	**Zahra Noori**



Comments

LMS: Normal.

LAD: No critical lesion .

CX: No critical lesion .

RCA: No critical lesion .

Decision:. *For Medical Treatment .*

Signature
د.محمد مطر

"Echocardiography Unit"

AZADI General Hospital DOHUK.
Department OF Medicine.
COLOR DOPPLER ECHOCAOCARDIOGRAPHY REPORT.

Patient Name:	From Dr.:
Age: Sex:	Date: 11 / 11 / 2009

Findings:

left ventricle dysfunction

E.F: 0.38

Examiner:

11 / 11 / 2009

Ministry of Health
DOH Duhok
Azadi Teaching Hospita

Kurdistan Region-Iraq

وەزارەتا تەندروستی
فەرمانگەها ساخلەمیا دهوکی
نەخوشخانا ئازادي

Exercise test

From Dr. :- د. برهان الدين

Patient name: - .... sex: - .
Patient ID: - ....
Age: - ...40 yrs...
Occupation: - ....كاسب..........
Date: -21../ 11 / 2009.

Indication of test: ....

....

• **Risk Factors**

HT		**Smoking**	
Diabetes		**HF**	
Hyperlipidaemia		**Other(s)**	

• **Exercise Protocol :**

Stage	HR	BP	Symptoms	Clinical Examination	ECG Changes
O	100	110/80			
I	118				
II	130	120/80			
III	126	130/80			
IV	144				
V	160	150/80			
VI					
Recovery					

• **Indication of stopping the test:**

Reached target	✓	**Chest pain**	x	**Arrhythmia**		**Others**	
Tiredness		**ECG changes**	x	**Dizziness**		**Dyspnea**	

• ***Report:***

Exercise capacity		**HR**	160	**BP**	150 / 80 mmHg
ECG changes					
Stage Reached	✓	**Conclusion**	Negative TMT		

Notes: -

Date: ….../….. /……..……
Name & signature of Doctor
Dr. Reber

EMC

سەنتەری چارەسەری فریاگوزاری

Emergency Management Center

سەنتەری هەولێر بۆ نەشتەرگەری دڵ

………………………………………………………………………………

Name: **D.O.A:17/11/2008**

Age: 60years **D.O.D:-27/11/2008**

Sex: **File NO.:-2352**

Preoperative diagnosis

Ischemi heart disease.
LMS. Diseased.
LAD very critical ostial lesion.
CX critical mid bifurcating lesion.
RCA hazy ostial, critical mid,total distal occlusion.

……………Operative Note:-CABG X4

Median sternotomy:SVG………OM
SVG………..LAD
SVG………PDA
LIMA--------D1

Smoth operative and post operarive period.

Postoperative Treatment:-

1.Aldacton 25 mg 1x1
2.Burinex tab 1x1
3.Metaprolol 50 mg 1x1
4.Warfarin 5mg 1/2x 1
5.Asprin tab 100 mg 1x1
6.Atorvast 20mg 1x1
7.Metformin 5oo mg 1x2
8.Insuline 25 iu morning
15 iu evening (s/c)

To be check in 07/12/2008

Dr.Emad Ahmed Jamal
Consultant Cardiac Surgeon
Hawler Cardiac Center
Erbil

EMC

مركز هولير لجراحة القلب — سەنتەری هەولێر بۆ نەشتەرگەری دڵ

Cardiac Catheterization Report

Name:
Age: 62Y
File No: 6407
Gender:
Cath. Lab: 2

Catheterization No: 2068
Cardiologist: Dr. Kamal Nizamy
Procedures: PTCA.
Date : 20 .10.2009

Sample	Pressure
AO	145/75/105
LV	

Comments:
PCI RCA
After ballooning of critical distal RCA stent 3*18 Bx-SONIC 14 barrs good final result no complications
Plavix tab 1*1 for one month
Aspirin tab 1*1
Amliodepine tab 10 mg 1*1
Zocor tab 20 mg 1*1
Hygroton tab 50 mg 1*1

Cardiologist
Dr. Kamal Nizamy

EMC

سەنتەری چارەسەری فریاگوزاری

Emergency Management Center

سەنتەری هەولێر بۆ نەشتەرگەریی دڵ

Echocardiography Report

Name:

Age: 38 years *Sex:* *Date*24.2.2009

Measurements (in mm) Normal Values

Aortic Root Dimension		30-37
Aortic Cusps Separation		15-26
LA Dimension		19-40
RV Dimension		9-26
IVSd		6-11
LVED Dimension		37-56
LVES Dimension		25-37
Posterior Wall Thickness		6-9
Ejection Fraction		57-75
Percentage of FS		34-44%

Description

- **Normal size cardiac chambers.**
- **Normal cardiac valves function and structure.**
- **Normal LV motion pattern, preserved LV systolic & diastolic function.**
- **Normal pericardium**

Conclusion

- **Normal Echo & Doppler study**

Signature

Dr. Ossama H. Ahmmad

APPENDIX G

<u>In-depth description of FHIS modules:</u>

<u>Tables and Attributes</u>
Table 1 shows the oracle tables and their attributes that are required for Knowledge-base and Database (KB&DB) module of the Research and Development (R&D) unit in the FHIS.

Table 1: Oracle tables and attributes for KB&DB module

Tables and Attributes of DB	
Table Name	Attributes
art_pulse	"exam_art_pulse_id" number(38), "art_pulse_type" varchar2(2), "brachial_pre" varchar2(100), "brachial_post" varchar2(100), "radial_pre" varchar2(100), "radial_post" varchar2(100), "fermoral_pre" varchar2(100), "fermoral_post" varchar2(100), "dorsalies_pre" varchar2(100), "dorsalies_post" varchar2(100), "post_tibial_pre" varchar2(100), "post_tibial_post" varchar2(100), constraint "art_pulse_fk_exam_pk" foreign key ("exam_art_pulse_id") references "examinations" ("exam_id") validate , check ("exam_art_pulse_id" is not null) validate , check ("exam_art_pulse_id" is not null) validate
catheterizations	"cath_id" number(38), "exam_pat_id" number(38), "pat_bed_date" date, "pat_out_date" date, "cath_date" date, "pat_mode" varchar2(60), "pat_weight" varchar2(10), "pat_prepared_cath" varchar2(1), "pat_non_prepared_reason" varchar2(100), "pat_cosent_form" varchar2(1), "pat_rate" varchar2(30), "pat_pulse" varchar2(30), "pat_cyanosis" varchar2(1), "pat_edema" varchar2(1), "pat_pacemaker" varchar2(1), "pat_increase_jvp" varchar2(1), "pat_high_risk" varchar2(1), "pat_use_valve_replacement" varchar2(1), "valve_type" varchar2(200), "pat_early_complication" varchar2(200), "pat_late_complication" varchar2(200), "pat_discharge_criteria_cath" varchar2(300), "pat_get_belongings" varchar2(300), "hebarin_rate" varchar2(100), "result_lms" varchar2(300), "result_lad" varchar2(300), "result_lad_d" varchar2(300), "result_lad_s" varchar2(300), "result_cx" varchar2(300), "result_cx_om" varchar2(300), "result_rca" varchar2(300), "result_other1" varchar2(300), "result_other2" varchar2(300), "created_by" varchar2(100), "created_date" date, "procedure_result" varchar2(100), "procedure_successful_rate" varchar2(100), "procedure_unsuccessful_reason" varchar2(300), "doctor_notes" varchar2(300), "rare_case" varchar2(1), "cath_start_time_hour" varchar2(3), "cath_start_time_minut" varchar2(3), "cath_end_time_hour" varchar2(3), "cath_end_time_minut" varchar2(3), "procedure_duration" varchar2(5), "fluoroscopy_time_hour" varchar2(3), "fluoroscopy_time_minut" varchar2(3), "cath_lab_no" varchar2(5), "procedure_type" varchar2(200), "updated_date" date, "active" varchar2(1), "updated_by" varchar2(100), "cath_type" varchar2(30), "start_type_time" varchar2(2), "end_type_time" varchar2(2), constraint "cath_fk_exam_pk" foreign key ("exam_pat_id") references "examinations" ("exam_id") validate , constraint "cath_pk" primary key ("cath_id") validate
cathstaff	"cath_id" number(20), "role" varchar2(4), "m_id" number(20), constraint "cathstaffrolefk_rolepk" foreign key ("role") references "dhis"."staffrole" ("role_id") validate , constraint "cstafffk_cathpk" foreign key ("cath_id") references "catheterizations" ("cath_id") validate , constraint "cstafffk_mpk" foreign key ("m_id") references "doctor_profile" ("doctor_id") validate
countries	"country_id" char(2), "country_name" varchar2(50), "region_id" number, constraint "country_fk_region_pk" foreign key ("region_id") references "regions" ("region_id") validate , constraint "country_id_pk" primary key

	("country_id") validate , constraint "c_name_unq" unique ("country_name") validate
decisions	"d_id" number(38), "d_name" varchar2(400), "d_description" varchar2(400), "d_type" varchar2(1), constraint "decisions_id_pk" primary key ("d_id") validate , check ("d_id" is not null) validate , check ("d_name" is not null) validate
decision_level	"l_id" varchar2(4), "level_name" varchar2(50), constraint "levelpk" primary key ("l_id") validate
departments	"department_id" number(38), "department_name" varchar2(100), "location_id" number(38), constraint "department_fk_location_pk" foreign key ("location_id") references "locations" ("location_id") validate , constraint "depart_id_pk" primary key ("department_id") validate , constraint "depart_name_unq" unique ("department_name") validate
doctor_profile	"doctor_id" number(38), "dr_first_name" varchar2(30), "dr_mid_name" varchar2(60), "dr_last_name" varchar2(30), "dr_birthdate" date, "dr_gender" varchar2(1), "dr_tel" varchar2(50), "dr_hand_phone" varchar2(50), "dr_fax" varchar2(50), "dr_specialization" varchar2(200), "dr_type" varchar2(100), "dr_email" varchar2(50), "department_id" number(38), "mtype_id" number(2), "member_experience" varchar2(200), "comments" varchar2(300), constraint "doctor_fk_depart_pk" foreign key ("department_id") references "departments" ("department_id") validate , constraint "doctor_id_pk" primary key ("doctor_id") validate , constraint "memtyppefk_mpk" foreign key ("mtype_id") references "member_type" ("mtype_id") validate , check ("doctor_id" is not null) validate , check ("dr_first_name" is not null) validate , check ("dr_last_name" is not null) validate , check ("dr_specialization" is not null) validate , check ("dr_type" is not null) validate
ecg	"ecg_id" number(38), "exam_id" number(38), "ecg_result" varchar2(300), "ecg_date" date, "doctor_id" number(38), "doctor_description" varchar2(300), "doctor_d_date" date, "created_by" varchar2(100), "created_date" date, "active" varchar2(1), "updated_by" varchar2(100), "updated_date" date, constraint "ecg_fk_doctor_pk" foreign key ("doctor_id") references "doctor_profile" ("doctor_id") validate , constraint "ecg_fk_exam_pk" foreign key ("exam_id") references "examinations" ("exam_id") validate , constraint "ecg_pk" primary key ("ecg_id") validate , check ("ecg_id" is not null) validate , check ("exam_id" is not null) validate , check ("doctor_id" is not null) validate
echo	"echo_id" number(38), "exam_id" number(38), "aortic_root_dimension" varchar2(5), "aortic_cusps_separation" varchar2(5), "la_dimension" varchar2(5), "rv_dimension" varchar2(5), "iv_sd" varchar2(5), "lved_dimension" varchar2(5), "lves_dimension" varchar2(5), "posterior_wall_thickness" varchar2(5), "ejection_fraction" varchar2(5), "percentage_of_fs" varchar2(5), "echo_description" varchar2(500), "echo_conclusion" varchar2(500), "doctor_id" number(38), "echo_date" date, "created_by" varchar2(100), "created_date" date, "active" varchar2(1), "updated_by" varchar2(100), "updated_date" date, constraint "echo_fk_doctor_pk" foreign key ("doctor_id") references "doctor_profile" ("doctor_id") validate , constraint "echo_fk_exam_pk" foreign key ("exam_id") references "examinations" ("exam_id") validate , constraint "echo_pk" primary key ("echo_id") validate , check ("echo_id" is not null) validate , check ("exam_id" is not null) validate
examinations	"exam_id" number(30), "pat_id" number(20), "pat_pr" varchar2(30), "pat_bp" varchar2(30), "pat_temp" varchar2(30), "pat_rr" varchar2(30), "pat_chest" varchar2(100), "pat_heart" varchar2(100), "pat_abdomen" varchar2(100), "pat_cns" varchar2(100), "pat_general_other1" varchar2(100), "pat_general_other2" varchar2(100), "pat_extremities" varchar2(100), "pat_exam_date" date, "doctor_id" number(38), "doctor_first_diagnosis" varchar2(500), "doctor_notes" varchar2(300), "doctor_final_diagnosis" varchar2(500), "final_d_date" date, "created_by" varchar2(100), "created_date"

	date default null , "updated_by" varchar2(100) default null , "updated_date" date default null , "exam_status" varchar2(100) default 'new' , "active" varchar2(1) default 'y' , "pat_status_after_treatment" varchar2(1) default 'l' , "exam_p_weight" varchar2(10), "exa_p_height" varchar2(10), "rare_case" varchar2(1), "mt_suce_result" varchar2(100), "mt_unsuc_reason" varchar2(200), constraint "exam_fk_doctor_pk" foreign key ("doctor_id") references "doctor_profile" ("doctor_id") validate , constraint "exam_id_pk" primary key ("exam_id") validate , constraint "pat_id_fk_to__pk" foreign key ("pat_id") references "patient_profile" ("pat_id") validate , check ("pat_id" is not null) validate , check ("created_by" is not null) validate , check ("created_date" is not null) validate , check ("exam_id" is not null) validate , check ("pat_id" is not null) validate , check ("pat_exam_date" is not null) validate , check ("doctor_id" is not null) validate , check ("created_by" is not null) validate
exam_decision	"exam_id" number(38), "decision_id" number(38), "l_id" varchar2(4), constraint "decision_fk_exam_pk" foreign key ("exam_id") references "examinations" ("exam_id") validate , constraint "d_fk_d_pk" foreign key ("decision_id") references "decisions" ("d_id") validate , constraint "edfk_dlpk" foreign key ("l_id") references "decision_level" ("l_id") validate , check ("exam_id" is not null) validate , check ("decision_id" is not null) validate
exercise	"exer_id" number(38), "exam_id" number(38), "indication_test" varchar2(400), "exer_capacity" varchar2(15), "exer_conclusion" varchar2(200), "exer_date" date, "doctor_id" number(38), "doctor_notes" varchar2(500), "created_by" varchar2(100), "created_date" date, "active" varchar2(1), "updated_by" varchar2(100), "updated_date" date, "other" varchar2(500), constraint "exer_fk_doctor_pk" foreign key ("doctor_id") references "doctor_profile" ("doctor_id") validate , constraint "exer_fk_exam_pk" foreign key ("exam_id") references "examinations" ("exam_id") validate , constraint "exer_id_pk" primary key ("exer_id") validate , check ("exer_id" is not null) validate , check ("exam_id" is not null) validate , check ("exer_date" is not null) validate , check ("doctor_id" is not null) validate , check ("created_by" is not null) validate , check ("created_date" is not null) validate
exercise_indication	"exer_id" number(38), "indication_id" varchar2(4), "comments" varchar2(500), constraint "exerfk_indicpk" foreign key ("indication_id") references "dhis"."indications" ("indication_id") validate , constraint "exer_indic_fk_exer_pk" foreign key ("exer_id") references "exercise" ("exer_id") validate
exercise_levels	"exer_id" number(38), "stage_number" varchar2(3), "hr_pulse" varchar2(10), "bp" varchar2(10), "symptoms" varchar2(400), "ecg" varchar2(400), "clinexam" varchar2(400), constraint "exer_fk_exer_pk" foreign key ("exer_id") references "dhis"."exercise" ("exer_id") validate , constraint "stage_n_unq" unique ("stage_number") validate , check ("exer_id" is not null) validate , check ("stage_number" is not null) validate
illness	"ill_id" varchar2(10), "ill_type" varchar2(100), constraint "ill_pk" primary key ("ill_id") validate , check ("ill_id" is not null) validate
indications	"indication_id" varchar2(4), "indication_name" varchar2(20), constraint "indication_pk" primary key ("indication_id") validate , constraint "indic_name_unq" unique ("indication_name") validate
investigations	"inve_id" number(38), "exam_id" number(38), "pat_cbp" varchar2(100), "pat_blood_urea" varchar2(100), "pat_serum_creatinine" varchar2(100), "pat_hepatities_b" varchar2(100), "pat_hepatities_c" varchar2(100), "pat_hiv" varchar2(100), "pat_pt_ink" varchar2(100), "pat_pit" varchar2(100), "pat_clotting_time" varchar2(100), "pat_bleeding_time" varchar2(100), "pat_blood_sugar" varchar2(100), "pat_triglycerides" varchar2(100), "pat_cholesterol" varchar2(100), "inve_date" date, "created_by" varchar2(100), "created_date" date, "active" varchar2(1), "updated_by" varchar2(100), "updated_date" date, constraint "inve_fk_exam_pk" foreign key ("exam_id")

	references "examinations" ("exam_id") validate , constraint "inve_pk" primary key ("inve_id") validate , check ("inve_date" is not null) validate , check ("inve_id" is not null) validate , check ("exam_id" is not null) validate
locations	"location_id" number(2), "hospital_name" varchar2(100), "address" varchar2(50), "postal_code" varchar2(20), "city" varchar2(30), "state_province" varchar2(30), "country_id" char(2), constraint "location_id_pk" primary key ("location_id") validate , constraint "loc_fk_coun_pk" foreign key ("country_id") references "countries" ("country_id") validate
medical_treatment	"mt_id" number(38), "exam_id" number(38), "product_name" varchar2(300), "usage_mode" varchar2(500), "description" varchar2(500), "duration" varchar2(10), "quantity" varchar2(100), "mt_date" date, "mt_reason" varchar2(500), "product_type" varchar2(100), "dose" varchar2(100), "times_day" number(1), constraint "mtpk" primary key ("mt_id") validate , constraint "mt_fk_exam_pk" foreign key ("exam_id") references "examinations" ("exam_id") validate , check ("exam_id" is not null) validate , check ("product_name" is not null) validate
members	"member_id" number(38), "first_name" varchar2(30), "mid_name" varchar2(40), "last_name" varchar2(30), "email" varchar2(50), "phone_number" varchar2(100), "mtype_id" number(2), "member_experience" varchar2(100), "department_id" number(38), "birthdate" date, "gender" varchar2(1), constraint "member_id_pk" primary key ("member_id") validate , constraint "memb_fk_depart_pk" foreign key ("department_id") references "departments" ("department_id") validate , constraint "m_fk_mt_pk" foreign key ("mtype_id") references "member_type" ("mtype_id") validate
member_type	"mtype_id" number(2), "member_type" varchar2(100), constraint "member_type_unq" unique ("member_type") validate , constraint "mtype_pk" primary key ("mtype_id") validate
patient_profile	"pat_id" number(20), "pat_prn" varchar2(30), "pat_first_name" varchar2(30), "pat_middle_name" varchar2(60), "pat_last_name" varchar2(30), "pat_address1" varchar2(50), "pat_address2" varchar2(50), "pat_address3" varchar2(50), "pat_city" varchar2(30), "pat_state_province" varchar2(30), "pat_post_code" varchar2(30), "pat_tel" varchar2(30), "pat_hand_phone" varchar2(30), "pat_fax" varchar2(30), "pat_dob" date, "pat_age" varchar2(10), "pat_ic_no_1" varchar2(20), "pat_ic_no_2" varchar2(20), "pat_passport_no" varchar2(30), "pat_passport_country" varchar2(30), "pat_gender" varchar2(1), "pat_race" varchar2(30), "pat_religion" varchar2(30), "pat_marital_status" varchar2(30), "pat_preferred_language" varchar2(60), "pat_height" varchar2(10), "pat_weight" varchar2(10), "pat_occupation" varchar2(30), "pat_education" varchar2(30), "pat_patient_type" varchar2(30), "pat_family_history_ht" varchar2(50), "pat_family_history_dn" varchar2(50), "pat_family_history_ihd" varchar2(50), "pat_drink_alcohol" varchar2(1), "pat_drink_alcohol_freq" varchar2(30), "pat_smoking" varchar2(1), "pat_smoking_stick_day" number(2), "pat_previous_illness" varchar2(100), "pat_previous_illness_other" varchar2(100), "created_date" date default null , "created_by" varchar2(100), "last_updated_date" date, "updated_by" varchar2(100), "active" varchar2(1) default 'y' , constraint "pat_id_pk" primary key ("pat_id") validate , check ("pat_prn" is not null) validate , check ("pat_first_name" is not null) validate , check ("created_date" is not null) validate , check ("created_by" is not null) validate
patmonitor	"pat_id" number(38), "exam_date" date, "exam_id" number(38), "hall" varchar2(50), "bed_number" varchar2(20), "bed_date" date, "out_date" date, "remarks" varchar2(500), constraint "patmonitorfkpatpk" foreign key ("pat_id") references "patient_profile" ("pat_id") validate
pat_illness	"pat_id" number(20), "illness_id" varchar2(10), "comments" varchar2(500), constraint "ill_pk_ill_fk" foreign key ("illness_id") references "illness" ("ill_id") validate , constraint "p_pk_ill_fk" foreign key ("pat_id") references

	"patient_profile" ("pat_id") validate , check ("pat_id" is not null) validate , check ("illness_id" is not null) validate
pci	"pci_id" number(38), "cath_id" number(38), "pci_code" varchar2(100), "pci_name" varchar2(100), "pci_type" varchar2(100), "pci_size" varchar2(100), "pci_bars" varchar2(100), "notes" varchar2(300), constraint "pci_cod_unq" unique ("pci_code") validate , constraint "pci_fk_cath_pk" foreign key ("cath_id") references "dhis"."catheterizations" ("cath_id") validate , constraint "pci_pk" primary key ("pci_id") validate , check ("pci_id" is not null) validate , check ("cath_id" is not null) validate , check ("pci_code" is not null) validate
regions	"region_id" number, "region_name" varchar2(50), constraint "region_id_pk" primary key ("region_id") validate , constraint "reg_name_unq" unique ("region_name") validate
samppressure	"samp_cath_id" number(38), "sample" varchar2(100), "pressure" varchar2(100), "o2sat" varchar2(100), constraint "samp_fk_cath_pk" foreign key ("samp_cath_id") references "catheterizations" ("cath_id") validate
schedules	"schedule_id" number(38), "sched_date" date, "doctor_id" number(38), "department_id" number(38), "sched_type_id" number(38), "updated_by" varchar2(100), "updated_date" date, "doctor_status" varchar2(100), "doctor_postponed_date" date, "postponed_duration" varchar2(200), "active" varchar2(1) default 'y' , constraint "doctor_sch_fk_sch_pk" foreign key ("schedule_id") references "schedule_duration" ("sche_id") validate , constraint "sch_fk_depart_pk" foreign key ("department_id") references "departments" ("department_id") validate , constraint "sch_fk_doctor_pk" foreign key ("doctor_id") references "doctor_profile" ("doctor_id") validate , constraint "sch_fk_sch_type_pk" foreign key ("sched_type_id") references "sched_type" ("sched_id") validate , check ("schedule_id" is not null) validate , check ("sched_date" is not null) validate , check ("doctor_id" is not null) validate , check ("department_id" is not null) validate , check ("sched_type_id" is not null) validate , check ("doctor_status" is not null) validate , check ("active" is not null) validate
schedule_duration	"sche_id" number(38), "start_date" date, "end_date" date, "created_by" varchar2(100), "created_date" date, constraint "sch_id_pk" primary key ("sche_id") validate , check ("sche_id" is not null) validate , check ("start_date" is not null) validate , check ("end_date" is not null) validate
sched_type	"sched_id" number(38), "sched_type" varchar2(2), "duration_time" varchar2(100), constraint "sch_type_pk" primary key ("sched_id") validate
staffrole	"role_id" varchar2(4), "role_name" varchar2(100), constraint "rolepk" primary key ("role_id") validate
surgery	"sur_id" number(38), "exam_id" number(38), "op_date" date, "op_type" varchar2(500), "op_result" varchar2(500), "op_successful_rate" varchar2(4), "op_unsuccessful_reason" varchar2(500), "pat_early_complications" varchar2(500), "op_start_time_h" varchar2(3), "op_start_time_m" varchar2(3), "op_end_time_h" varchar2(3), "op_end_time_m" varchar2(3), "op_duration" varchar2(10), "op_notes" varchar2(500), "created_by" varchar2(100), "created_date" date, "rare_case" varchar2(1), "updated_date" date, "active" varchar2(1), "updated_by" varchar2(100), "pat_late_complications" varchar2(500), "start_type_time" varchar2(2), "end_type_time" varchar2(2), constraint "surfkexampk" foreign key ("exam_id") references "examinations" ("exam_id") validate , constraint "surpk" primary key ("sur_id") validate
surgerystaff	"sur_id" number(38), "role" varchar2(4), "ms_id" number(38), constraint "stafffk_surgpk" foreign key ("sur_id") references "surgery" ("sur_id") validate , constraint "surfkstaffpk" foreign key ("ms_id") references "doctor_profile" ("doctor_id") validate , constraint "surfkstaffrolepk" foreign key ("role") references "staffrole" ("role_id") validate

vitalsigns	"cath_pat_v_s_id" number(38), "signs_bp" varchar2(50), "signs_pulse" varchar2(50), "signs_temp" varchar2(50), "signs_rr" varchar2(50), "signs_pain" varchar2(50), "signs_type" varchar2(50), "remark" varchar2(200), "checked_by" varchar2(100), "signs_date" date, "signs_time_hour" varchar2(3), "signs_time_minut" varchar2(3), check ("cath_pat_v_s_id" is not null) validate , constraint "vitalsig_fk_cath_pk" foreign key ("cath_pat_v_s_id") references "catheterizations" ("cath_id") validate
Tables and Attributes of KB	
Table Name	Attributes
cabg_treatment	"d_id" number(38), "how_treat" varchar2(20), "operation_type" varchar2(500), "operation_duration" varchar2(10), "operation_result" varchar2(500), "operation_successful_rate" varchar2(4), "pat_complications" varchar2(500), "operation_notes" varchar2(500), constraint "cabg_fk_treat_pk" foreign key ("d_id", "how_treat") references "dkb"."treatments" ("d_id", "how_treat") validate
diagnosises	"d_id" number(38), "doctor_id" number(20), "pat_id" number(20), "diagnosis" varchar2(100), "d_level" varchar2(100), "activity_date" date, constraint "diagnosis_pk" primary key ("d_id") validate
medical_treatment	"d_id" number(38), "how_treat" varchar2(20), "medical_treatment" varchar2(500), constraint "medi_fk_treat_pk" foreign key ("d_id", "how_treat") references "dkb"."treatments" ("d_id", "how_treat") validate
patient_attributes	"d_id" number(38), "attr_name" varchar2(100), "value" varchar2(500), "deci_l" varchar2(50), constraint "attr_fk_diag_pk" foreign key ("d_id") references "dkb"."diagnosises" ("d_id") validate
pci_treatment	"d_id" number(20), "how_treat" varchar2(20), "pci_name" varchar2(100), "pci_type" varchar2(100), "pci_size" varchar2(100), "pci_bars" varchar2(100), "procedure_type" varchar2(200), "procedure_result" varchar2(100), "procedure_successful_rate" varchar2(100), "pat_complications" varchar2(300), constraint "pci_fk_treat_pk" foreign key ("d_id", "how_treat") references "dkb"."treatments" ("d_id", "how_treat") validate
rare_cases	"d_id" number(20), "how_treat" varchar2(20), "full_name" varchar2(100), "role" varchar2(100), "position" varchar2(100), constraint "rare_fk_treat_pk" foreign key ("d_id", "how_treat") references "dkb"."treatments" ("d_id", "how_treat") validate
treatments	"d_id" number(38), "how_treat" varchar2(100), "rare_case" varchar2(1) default 'n' , "t_date" date, constraint "treat_fk_diag_pk" foreign key ("d_id") references "dkb"."diagnosises" ("d_id") validate , constraint "treat_uniq" unique ("d_id", "how_treat") validate

Pseudo Code of the R&D Unit Modules

Table 2 shows the pseudo code of the R&D unit modules in the FHIS. These modules are:

1. Controller (C) Module
2. Analyzer and Planer (A&P) Module
3. Executer (E) Module

Table 2: Pseudo code of the R&D unit modules

Module Name	Pseudo-code
Controller (c)	

Trigger CTRMOD	After update of column exam_status on the table examinations
	begin
	open examid_cursor on the table examinations
	loop
	fetch examid_cursor into consid
	exit when examid_cursor%notfound
	end loop
	close examid_cursor
	if :new.exam_status equal 'completed' and :old.exam_status not equal ' completed' then
	call a&p module procedure (with parameter consid) to check related data in the database
	else if :new.exam_status not equal 'completed' and :old.exam_status equal 'completed' then
	treatment equal 'incomplete'
	call A&P module procedure with parameter consid and treatment to delete related data from knowledge-base
	end if
	end if
	end

Trigger CTRSCHEDULE	After insert on the table schedule_duration begin call a&p module procedure to consider the schedule updating end
Trigger CTRSTATISTIC	After insert on the table patient_profile begin call a&p module procedure to update the statistic information end
Trigger SURG_RARECASE_CTR	

	After update of column rare_case on the table surgery
	
	begin
	
	open examid_cursor on the table surgery
	
	loop
	
	fetch examid_cursor into consid
	
	exit when examid_cursor%notfound
	
	end loop
	
	close examid_cursor
	
	treatment equal 'surgery'
	
	if :new.rare_case equal 'y' and :old.rare_case not equal 'y' then
	
	call a&p module procedure with parameter consid and treatment to update the data of patient treatment related to the surgery to rare case group
	
	else
	
	call a&p module procedure with parameter consid and treatment to delete the related data of patient treatment from knowledge base as the surgery rare case
	
	end if
	
	end

Trigger PCI_RARECASE_CTR	After update of column rare_case on the table catheterizations
	
	begin
	
	open examid_cursor on the table catheterizations
	
	loop
	
	fetch examid_cursor into consid
	
	exit when examid_cursor%notfound
	
	end loop
	
	close examid_cursor
	
	treatment equal 'pci'
	
	if :new.rare_case equal 'y' and :old.rare_case not equal 'y' then
	
	call a&p module procedure with parameter consid and treatment to update the data of patient treatment related to the PCI to the rare case group
	
	else
	
	call a&p module procedure with parameter consid and treatment to delete the related data of patient treatment from knowledge base as PCI rare case

Trigger MEDI_RARECASE_CTR	end if
	
	end
	
	After update of column rare_case on the table examinations
	
	begin
	
	open examid_cursor on the table examinations
	
	loop
	
	fetch examid_cursor into consid
	
	exit when examid_cursor%notfound
	
	end loop
	
	close examid_cursor
	
	treatment equal ' Medication'
	
	if :new.rare_case equal 'y' and :old.rare_case not equal 'y' then
	
	call a&p module procedure with parameter consid and treatment to update the data of patient treatment related to the medication to the rare case group
	
	else
	
	call a&p module procedure with parameter consid and treatment to delete the related data of patient treatment from knowledge base as medication rare case
	
	end if
	
	end

Trigger CTRREMOTE	After insert or update of columns db_link, hospital_name and note_type on the table announcement of executer Note : (the description of the table announcement attributes are: "note_type" varchar2(100), "hospital_name" varchar2(100), "db_link" varchar2(100) begin open anner on the table announcement loop fetch anner into note, hospital, dblink exit when anner%notfound end loop close anner call a&p module procedure with parameter note, hospital and dblink to announce the new activity happened from other remote hospitals to make view on this activity

	end
Module Name	**Pseudo-code**
Analyser and Planner (A&P)	

procedure
 	
ap_m
	/* This procedure checks all data related to the activity that has been called by the C module */
	
	Procedure ap_m with one parameter (consid)
	
	begin
	
	    open consult_cursor on the table consultation
	
	        loop
	
	            fetch consult_cursor into final_diagno, pat_status
	
	            exit when consult_cursor%notfound
	
	        end loop
	
	    close consult_cursor
	
	    if pat_status equal 'l' and final_diagno not equal null then
	
	        open decismt_cursor on the table exam_decision
	
	            loop
	
	                fetch decismt_cursor into decis_mt
	
	                exit when decismt_cursor%notfound
	
	            end loop
	
	        close decismt_cursor
	
	        open decispci_cursor on the table exam_decision
	
	            loop
	
	                fetch decispci_cursor into decis_pci
	
	                exit when decispci_cursor%notfound
	
	            end loop
	
	        close decispci_cursor
	
	        open decissurg_cursor on the table exam_decision
	
	            loop
	
	                fetch decissurg_cursor into decis_surgery
	
	                exit when decissurg_cursor%notfound
	
	            end loop
	
	        close decissurg_cursor
	
	        open mt_case cursor on the table examinations
	
	            loop

	fetch mt_case into mt_success, mt_rare_case
	
	exit when mt_case%notfound
	
	end loop
	
	close mt_case cursor
	
	open pci_case cursor on the table catheterizations
	
	loop
	
	fetch pci_case into pci_success, pci_rare_case
	
	exit when pci_case%notfound
	
	end loop
	
	close pci_case cursor
	
	open surg_case cursor on the table surgery
	
	loop
	
	fetch surg_case into surgery_success, surgery_rare_case
	exit when surg_case%notfound
	end loop
	close surg_case cursor
	
	if mt_success equal 'successful' or pci_success equal 'successful' or surgery_success equal 'successful' then
	
	call Executer (E) module procedure with parameters (consid, decis_mt, mt_rare_case, decis_pci, pci_rare_case, decis_surgery, surgery_rare_case) to fetch all data related to the activity from database to knowledge-base to record as a new knowledge
	
	end if
	
	end if
	
	end

procedure
 	
ap_d
	/* This procedure checks if id available in knowledg base or not for delete all related data when any upgrade has done for old data (e.g. change the status of patient treatment from completed to incomplete)*/
	
	procedure ap_d with two parameters (consid and treatment)
	
	begin
	
	select consultation id into decisid from the table diagnosises where id = consid
	
	if decisid equal consid then
	
	call E module procedure with parameters consid and treatment to delete all related data from knowledge base tables
	
	end if

Procedure
 	
ap_ckracs
	end
	
	/* Procedure to check if id available in knowledg base or not for add rare case details*/
	
	procedure ap_ckracs with parameters (consid and treatment)
	
	begin
	
	    select consultation id into decisid from diagnosises where the id equal consid
	
	    if decisid equal consid then
	
	        call E module procedure with parameters consid and treatment to add a rare case details when update happened for patient treatment to the rare case
	
	    end if
	
	end

Procedure Ap_schedule	/* This procedure tries to announce for new schedule has been created*/ procedure ap_schedule begin call E module procedure to send the announcement of creating a new schedule for physicians to other remote hospitals end
Procedure ap_statistic	/* This procedure tries to announce for new statistic has been created*/ procedure ap_statistic begin call E module procedure to announce other hospitals of changing the statistical information end

Procedure
 	
Announce
	/*This procedure calls other procedures in the E module to create view on the new announcement that has been got from remote hospitals */
	
	procedure announce with parameters (note, hospital, dblink)
	
	begin
	
	    if note equal 'case' then
	
	        call E module procedure with parameters (note, hospital, dblink) to create view on the new case of patient treatment from remote hospitals

<table>
<tr><td></td><td>
<pre>
     else
          if note equal 'schedule' then
                call E module procedure with parameters (note, hospital, dblink) to create view on the new schedule of physicians from remote hospitals
          else
               if note equal 'statistic' then
                    call E module procedure with parameters (note, hospital, dblink) to create view on the new statistic information from remote hospitals
               end if
          end if
     end if
end
</pre>
</td></tr>
<tr><th>Module Name</th><th>Pseudo-code</th></tr>
<tr><td colspan="2">Executer (E)</td></tr>
<tr><td>Procedure

Exec_mod1</td><td>
<pre>
/* This procedure fetches all related data from database part to knowledge-base part in KB&DB module of R&D unit when it is received a message from A&P module about a new complete patient treatment has done in a local hospital */

procedure exec_mod1 with 7 parameters (consid, decis_mt, mt_rare_case, decis_pci, pci_rare_case, decis_surgery, surgery_rare_case)

begin

/* determine the maximum level of decision by doctor */
   open maxlevel_cursor on the exam_decision table
          loop
                fetch maxlevel_cursor into maxlevel
                exit when maxlevel_cursor%notfound
          end loop
   close maxlevel_cursor
   /* -------------------------end--*/
   if maxlevel equal 4 then
   begin
     /* Determine the second max level of decision by doctor */
       open second max level cursor
</pre>
</td></tr>
</table>

	loop
	
	fetch second max level cursor into sndmaxlevel
	
	exit when second max level cursor %notfound
	
	end loop
	
	close second max level cursor
	
	/* insert doctor diagnosis into diagnosises table */
	
	insert into the diagnosises table (decision id, decision level, diagnosis, doctor id, patient id, activity date) (select examination id,(select decision level name from the decision level table where decision level id equal sndmaxlevel) , doctor's final diagnosis, doctor id, patient id, current date as activity date from the examinations table where examination id equal consid)
	
	end
	
	else
	
	insert into the diagnosises table (decision id, decision level, diagnosis, doctor id, patient id, activity date) (select examination id,(select decision level name from the decision level table where decision level id equal maxlevel) , doctor's final diagnosis, doctor id, patient id, current date as activity date from the examinations table where examination id equal consid)
	
	end if
	
	/* ------------------------end---*/
	
	/* insert patient profile attributes into patient attributes table */
	
	open pat_cursor on the patient_profile and examinations tables
	
	loop
	
	fetch pat_cursor into age, gender, smoking, drink_alcohol, family_h_ihd, family_h_dn, family_h_ht, exit when pat_cursor%notfound
	
	end loop
	
	close pat_cursor
	
	p_prof equal pat_pro (age, gender, smoking, drink_alcohol, family_h_ihd, family_h_dn, family_h_ht)
	
	j equal zero
	
	for i in first attributes to last attributes of patient
	
	loop
	
	j equal j plus one
	
	if p_prof(j) not equal null then
	
	insert into the patient_attributes table values (consid,attributes_p(i), p_prof(j))

	end if
	
	end loop
	
	/* -------------------------end---*/
	
	/* insert consultation attributes of patient into patient attributes table */
	
	open exam_cursor on the examinations table
	
	loop
	
	fetch exam_cursor into height, weight, bp, temp, rr, pr, heart, cns, chest, abdomen, extremities, other, exit when exam_cursor%notfound
	
	end loop
	
	close exam_cursor
	
	p_prof := pat_pro(height, weight, bp, temp, rr, pr, heart, cns, chest, abdomen, extremities, other)
	
	j equal zero
	
	for i in first attribute to last attribute of patient
	
	loop
	
	j equal j plus one
	
	if p_prof(j) not equal null then
	
	insert into patient_attributes table values (consid,cons_attr_p(i), p_prof(j))
	
	end if
	
	end loop
	
	/* -------------------------end---*/
	
	/* insert echo results into patient attributes table */
	
	open echo_cursor on the echo table
	
	loop
	
	fetch echo_cursor into echo_result, exit when echo_cursor%notfound
	
	end loop
	
	close echo_cursor;
	
	if echo_result not equal null then
	
	insert into patient_attributes table values (consid, 'echo result', echo_result)
	
	end if
	
	/*-------------------------end--------------------------------------*/
	
	/* insert ecg results into patient attributes table */

	open ecg_cursor on the ecg table
	
	loop
	
	fetch ecg_cursor into ecg_result, exit when ecg_cursor%notfound
	
	end loop
	
	close ecg_cursor
	
	if ecg_result not equal null then
	
	insert into patient_attributes table values (consid, 'ecg result', ecg_result)
	
	end if
	
	/*-----------------------------end---------------------------------------*/
	
	/* insert lab results into patient attributes table */
	
	open labinv_cursor on the investigations table
	
	loop
	
	fetch labinv_cursor into cbp, serum, triglycerides, cholesterol, hepat_b, hepat_c, hiv, ink, pit, clotting_time, bleeding_time, blood_ur, blood_su, exit when labinv_cursor%notfound
	
	end loop
	
	close labinv_cursor
	
	p_prof equal pat_pro(cbp, serum, triglycerides, cholesterol, hepat_b, hepat_c, hiv, ink, pit, clotting_time, bleeding_time, blood_ur, blood_su)
	
	j equal zero
	
	for i in first attribute to last attributes of patient
	
	loop
	
	j equal j plus one
	
	if p_prof(j) not equal null then
	
	insert into patient_attributes table values (consid,labinv_attr(i), p_prof(j))
	
	end if
	
	end loop
	
	/*----------------------------end-----------------------------------*/
	
	/* insert exercise results into patient attributes table */
	
	open maxstage_cursor on the exercise_levels and exercise tables
	
	loop
	
	fetch maxstage_cursor into maxstage, exit when maxstage_cursor%notfound

```
        end loop

    close maxstage_cursor

    open exerci_cursor on the exercise table

        loop

            fetch exerci_cursor into exer_capacity, exer_result,
            exit when exerci_cursor%notfound

        end loop

    close exerci_cursor

    if exer_result not equal null then

        insert into patient_attributes table values (consid, 'exercise
        capacity', exer_capacity)

        insert into patient_attributes table values (consid, 'exercise
        stage reached', maxstage)

        insert into patient_attributes table values (consid, 'exercise
        result', exer_result)

    end if

    /*----------------------------------end-----------------------------------*/

    /* insert catheterization results into patient attributes table */

    open cath_cursor on the catheterizations table

        loop

            fetch cath_cursor into lms, lad, lad_d, lad_s, cx,
            cx_om, rca, other1, other2, exit when
            cath_cursor%notfound

        end loop

    close cath_cursor

    p_prof  equal pat_pro(lms, lad, lad_d, lad_s, cx, cx_om, rca, other1,
    other2)

    j equal zero

    for i in first result of catheter to last result of catheter done for
    patient

        loop

            j equal j plus one

            if p_prof(j) not equal null then

                insert into patient_attributes table values
                (consid,cath_result(i), p_prof(j))

            end if

        end loop

    /*----------------------------------end-----------------------------------*/
```

	/* insert treatment information into treatments tables*/
	
	open decimt_cursor on the decisions table
	
	loop
	
	fetch decimt_cursor into decisionmt, exit when decimt_cursor%notfound
	
	end loop
	
	close decimt_cursor
	
	open decipci_cursor on the decisions table
	
	loop
	
	fetch decipci_cursor into decisionpci, exit when decipci_cursor%notfound
	
	end loop
	
	close decipci_cursor
	
	open decisurg_cursor on the decisions table
	
	loop
	
	fetch decisurg_cursor into decisionsurg, exit when decisurg_cursor%notfound
	
	end loop
	
	close decisurg_cursor
	
	/* insert medical treatment information into treatments tables*/
	
	if decisionmt not equal null then
	
	if decisionpci not equal null then
	
	if decisionsurg not equal null then
	
	insert into treatments table values selected from the surgery table as consid, decisionsurg , su.rare_case, su.op_date where examination id equal consid
	
	if surgery_rare_case equal 'y' then
	
	open surgery_drname on the exam_decision table
	
	loop
	
	fetch surgery_drname into opresult, exit when surgery_drname%notfound
	
	if opresult equal 'successful' then
	
	open doctor_surgery on the surgerystaff and surgery tables
	
	loop
	
	fetch doctor_surgery into membstaff, rolesurg, exit when doctor_surgery%notfound

	<pre>select doctor full name, doctor position into fullnamesurg, positionsurg from the doctor_profile table where doctor id equal membstaff
	
	select role name into rolenamesurg from the staffrole table where role id equal rolesurg
	
	insert into rare_cases table values (consid, decisionsurg, fullnamesurg, positionsurg, rolenamesurg)
	
	end loop
	
	end if
	
	end loop
	
	close doctor_surgery;
	
	close surgery_drname;
	
	end if
	
	open exam_surgery on the surgery table
	
	loop
	
	fetch exam_surgery into optype, opduration, opresult, oprate, patcompl, opnotes, opdate, exit when exam_surgery%notfound
	
	insert into cabg_treatment table values(consid, decisionsurg, optype, opduration, opresult, oprate, patcompl, opnotes)
	
	end loop
	
	close exam_surgery
	
	/*-----------------end--------------------*/
	
	/* insert pci treatment */
	
	insert into treatments table values selected from catheterizations table as consid, decisionpci, rare_case and cath_date where exam_pat_id equal consid and (cath_type equal 'ther' or cath_type equal 'diagther')
	
	if pci_rare_case equal 'y' then
	
	open cath_drname cursor on the catheterizations table
	
	loop
	
	fetch cath_drname into cathtype, exit when cath_drname%notfound
	
	if cathtype equal 'ther' or cathtype equal 'diagther' then
	
	open doctor_pci cursor on the catheterizations and cathstaff tables
	
	loop</pre>

	fetch doctor_pci into member, rolepci, exit when doctor_pci%notfound
	
	select doctor full name, doctor position into fullnamepci, positionpci from the doctor_profile table where doctor id equal member
	
	select role name into rolenamepci from the staffrole table where role id equal rolepci
	
	insert into the rare_cases table values (consid, decisionpci, fullnamepci, positionpci, rolenamepci)
	
	end loop
	
	end if
	
	end loop
	
	close doctor_pci
	
	close cath_drname
	
	end if
	
	open cath_pci cursor on the catheterizations table
	
	loop
	
	fetch cath_pci into protype, proresult, resultrate, pcicompl, cathdate, exit when cath_pci%notfound
	
	open pci_cursor on the pci and catheterizations tables
	
	loop
	
	fetch pci_cursor into bar, name, siz, pcityp, exit when pci_cursor%notfound
	
	insert into the pci_treatment table values(consid, decisionpci, bar, name, siz, pcityp, protype, proresult, resultrate, pcicompl)
	
	end loop
	
	end loop
	
	close pci_cursor
	
	close cath_pci cursor
	
	/* -------------end---------------*/
	
	/* insert medication treatment */
	
	insert into the treatments table values selected from examinations table as exam_id, decisionmt, rare_case, opdate where exam_id equal consid
	
	if medical treatment rare case equal 'y' then
	
	open doctor_medical cursor on the doctor_profile and examinations tables
	
	loop

	fetch doctor_medical into fullname, position, exit when doctor_medical%notfound
	
	insert into rare_cases table values(consid, decisionmt, fullname, position, 'doctor')
	
	end loop
	
	close doctor_medical cursor
	
	end if
	
	open medical_cursor on the medical_treatment table
	
	loop
	
	fetch medical_cursor into medication, exit when medical_cursor%notfound
	
	insert into medical_treatment table values (consid, decisionmt, medication)
	
	end loop
	
	close medical_cursor
	
	/*--------------end-----------*/
	
	else /* insert medication and pci into treatments */
	
	/* insert pci treatment */
	
	insert into treatments table values selected from catheterizations as consid, decisionpci, rare_case, cath_date where exam_pat_id equal consid and (cath_type equal 'ther' or cath_type equal 'diagther')
	
	if pci rare case equal 'y' then
	
	open cath_drname cursor on the catheterizations table
	
	loop
	
	fetch cath_drname into cathtype, exit when cath_drname%notfound
	
	if cathtype equal 'ther' or cathtype equal 'diagther' then
	
	open doctor_pci cursor on the catheterizations and cathstaff tables
	
	loop
	
	fetch doctor_pci into member, rolepci, exit when doctor_pci%notfound
	
	select doctor full name, doctor position into fullnamepci, positionpci from the doctor_profile table where doctor id equal member
	
	select role name into rolenamepci from the staffrole table where role id equal rolepci
	
	insert into rare_cases table values (consid, decisionpci, fullnamepci, positionpci, rolenamepci)

```
          end loop

        end if

      end loop

      close doctor_pci cursor

    close cath_drname cursor

    end if

    open cath_pci cursor on the catheterizations

      loop

        fetch cath_pci into protype, proresult, resultrate, pcicompl,
        cathdate, exit when cath_pci%notfound

        open pci_cursor on the pci and catheterizations tables

          loop

            fetch pci_cursor into bar, name, siz, pcityp, exit when
            pci_cursor%notfound

            insert into the pci_treatment table values(consid,
            decisionpci, bar, name, siz, pcityp, protype, proresult,
            resultrate, pcicompl)

          end loop

      end loop

    close pci_cursor

    close cath_pci cursor

    /* ------------end------------*/

    /* insert medication treatment */

    insert into the treatments table values selected from
    examinations table as exam_id, decisionmt, rare_case, cathdate
    where exam_id equal consid

    if medical treatment rare case equal 'y' then

      open doctor_medical;

        loop

          fetch doctor_medical into fullname, position, exit when
          doctor_medical%notfound

          insert into the rare_cases table values (consid, decisionmt,
          fullname, position, 'doctor')

        end loop

      close doctor_medical cursor

    end if

    open medical_cursor on the medical_treatment table
```

	loop
	
	fetch medical_cursor into medication, exit when medical_cursor%notfound
	
	insert into the medical_treatment table values (consid, decisionmt, medication)
	
	end loop
	
	close medical_cursor
	
	end if; /*----------------------------end----------------------------*/
	
	else /* insert medication and surgery into treatments */
	
	if decisionsurg not equal null then
	
	insert into the treatments table values selected from the surgery table as consid, decisionsurg, rare_case, op_date where exam_id equal consid
	
	if surgery rare case equal 'y' then
	
	open surgery_drname cursor on the surgery table
	
	loop
	
	fetch surgery_drname into opresult, exit when surgery_drname%notfound
	
	if opresult equal 'successful' then
	
	open doctor_surgery cursor on the surgerystaff and surgery tables
	
	loop
	
	fetch doctor_surgery into membstaff, rolesurg, exit when doctor_surgery%notfound
	
	select doctor full name, doctor position into fullnamesurg, positionsurg from the doctor_profile table where doctor id equal membstaff
	
	select role name into rolenamesurg from the staffrole table where role id equal rolesurg
	
	insert into the rare_cases table values (consid, decisionsurg, fullnamesurg, positionsurg, rolenamesurg)
	
	end loop
	
	end if
	
	end loop
	
	close doctor_surgery cursor
	
	close surgery_drname cursor
	
	end if
	
	open exam_surgery;

	loop
	
	fetch exam_surgery into optype, opduration, opresult, oprate, patcompl, opnotes, opdate, exit when exam_surgery%notfound
	
	insert into the cabg_treatment table values (consid,decisionsurg,optype, opduration, opresult, oprate, patcompl, opnotes)
	
	end loop
	
	close exam_surgery
	
	/*-----------------end--------------------*/
	
	/* insert medication treatment */
	
	insert into the treatments table values selected from examinations as exam_id, decisionmt, rare_case, opdate where exam_id equal consid
	
	if medical treatment rare case equal 'y' then
	
	open doctor_medical cursor on the doctor_profile and examinations tables
	
	loop
	
	fetch doctor_medical into fullname, position, exit when doctor_medical%notfound
	
	insert into the rare_cases table values (consid, decisionmt, fullname, position, 'doctor')
	
	end loop
	
	close doctor_medical cursor
	
	end if
	
	open medical_cursor on the medical_treatment table
	
	loop
	
	fetch medical_cursor into medication, exit when medical_cursor%notfound
	
	insert into the medical_treatment table values (consid, decisionmt, medication)
	
	end loop
	
	close medical_cursor
	
	/*--------------end-----------*/
	
	else
	
	/* insert medication into treatments */
	
	insert into the treatments table values selected from examinations as exam_id, decisionmt, rare_case, final_d_date where exam_id equal consid
	
	if medical treatment rare case equal 'y' then

	open doctor_medical cursor on the doctor_profile and examinations tables
	loop
	fetch doctor_medical into fullname, position, exit when doctor_medical%notfound
	insert into the rare_cases table values(consid, decisionmt, fullname, position, 'doctor')
	end loop
	close doctor_medical cursor
	end if
	open medical_cursor on the medical_treatment table
	loop
	fetch medical_cursor into medication, exit when medical_cursor%notfound
	insert into the medical_treatment table values (consid, decisionmt, medication)
	end loop
	close medical_cursor
	end if /*------------------end----------------------*/
	end if
	else /* insert pci and/or surgery treatment */
	if decisionpci not equal null then
	if decisionsurg not equal null then
	insert into the treatments table values selected from surgery as consid, decisionsurg, rare_case, op_date where exam_id equal consid
	if surgery rare case equal 'y' then
	open surgery_drname cursor on the surgery table
	loop
	fetch surgery_drname into opresult, exit when surgery_drname%notfound
	if opresult equal 'successful' then
	open doctor_surgery cursor on the surgerystaff and surgery tables
	loop
	fetch doctor_surgery into membstaff, rolesurg, exit when doctor_surgery%notfound
	select doctor full name, doctor position into fullnamesurg, positionsurg from the doctor_profile table

	where doctor id equal membstaff
	
	select role name into rolenamesurg from the staffrole table where role id equal rolesurg
	
	insert into the rare_cases table values (consid, decisionsurg, fullnamesurg, positionsurg, rolenamesurg)
	
	end loop
	
	end if
	
	end loop
	
	close doctor_surgery cursor
	
	close surgery_drname cursor
	
	end if
	
	open exam_surgery cursor on the surgery table
	
	loop
	
	fetch exam_surgery into optype, opduration, opresult, oprate, patcompl, opnotes, opdate, exit when exam_surgery%notfound
	
	insert into the cabg_treatment table values (consid,decisionsurg,optype, opduration, opresult, oprate, patcompl, opnotes)
	
	end loop
	
	close exam_surgery cursor
	
	/*-----------------end--------------------*/
	
	/* insert pci treatment */
	
	insert into the treatments table values selected from catheterizations as consid, decisionpci, rare_case, cath_date where exam_pat_id equal consid and (cath_type equal 'ther' or cath_type equal 'diagther')
	
	if pci rare case equal 'y' then
	
	open cath_drname cursor on the catheterizations table
	
	loop
	
	fetch cath_drname into cathtype, exit when cath_drname%notfound
	
	if cathtype equal 'ther' or cathtype equal 'diagther' then
	
	open doctor_pci cursor on the catheterizations and cathstaff tables
	
	loop
	
	fetch doctor_pci into member, rolepci, exit when doctor_pci%notfound
	
	select doctor full name, doctor position into fullnamepci, positionpci from the doctor_profile table where doctor id

	equal member
	
	select role name into rolenamepci from the staffrole table where role id equal rolepci
	
	insert into the rare_cases table values (consid, decisionpci, fullnamepci, positionpci, rolenamepci)
	
	end loop
	
	end if
	
	end loop
	
	close doctor_pci cursor
	
	close cath_drname cursor
	
	end if
	
	open cath_pci cursor on the catheterizations table
	
	loop
	
	fetch cath_pci into protype, proresult, resultrate, pcicompl, cathdate, exit when cath_pci%notfound
	
	open pci_cursor on the pci and catheterizations table
	
	loop
	
	fetch pci_cursor into bar, name, siz, pcityp, exit when pci_cursor%notfound
	
	insert into the pci_treatment table values(consid, decisionpci, bar, name, siz, pcityp, protype, proresult, resultrate, pcicompl)
	
	end loop
	
	end loop
	
	close pci_cursor
	
	close cath_pci cursor
	
	/* -------------end---------------*/
	
	else /* insert surgery or pci treatment */
	
	if decisionsurg not equal null then
	
	insert into the treatments table values selected from surgery as consid, decisionsurg, rare_case, op_date where exam_id equal consid
	
	if surgery rare case equal 'y' then
	
	open surgery_drname cursor on the surgery table
	
	loop
	
	fetch surgery_drname into opresult, exit when surgery_drname%notfound
	
	if opresult equal 'successful' then

	open doctor_surgery on the surgerystaff and surgery tables
	
	loop
	
	fetch doctor_surgery into membstaff, rolesurg, exit when doctor_surgery%notfound
	
	select doctor full name, doctor position into fullnamesurg, positionsurg from the doctor_profile table where doctor id equal membstaff
	
	select role name into rolenamesurg from the staffrole table where role id equal rolesurg
	
	insert into the rare_cases table values (consid, decisionsurg, fullnamesurg, positionsurg, rolenamesurg)
	
	end loop
	
	end if
	
	end loop
	
	close doctor_surgery cursor
	
	close surgery_drname cursor
	
	end if
	
	open exam_surgery cursor on the surgery table
	
	loop
	
	fetch exam_surgery into optype, opduration, opresult, oprate, patcompl, opnotes, opdate, exit when exam_surgery%notfound
	
	insert into the cabg_treatment table values (consid, decisionsurg, optype, opduration, opresult, oprate, patcompl, opnotes)
	
	end loop
	
	close exam_surgery cursor
	
	/*-----------------end--------------------*/
	
	else
	
	/* insert pci treatment */
	
	insert into the treatments table values selected from catheterizations as consid, decisionpci, rare_case, cath_date where exam_pat_id equal consid and (cath_type equal 'ther' or cath_type equal 'diagther')
	
	if pci rare case equal 'y' then
	
	open cath_drname cursor on the catheterizations table
	
	loop
	
	fetch cath_drname into cathtype, exit when

	cath_drname%notfound
	
	if cathtype equal 'ther' or cathtype equal 'diagther' then
	
	open doctor_pci cursor on the catheterizations and cathstaff tables
	
	loop
	
	fetch doctor_pci into member, rolepci, exit when doctor_pci%notfound
	
	select doctor full name, doctor position into fullnamepci, positionpci from the doctor_profile table where doctor id equal member
	
	select role name into rolenamepci from the staffrole table where role id equal rolepci
	
	insert into the rare_cases table values (consid, decisionpci, fullnamepci, positionpci, rolenamepci)
	
	end loop
	
	end if
	
	end loop
	
	close doctor_pci cursor
	
	close cath_drname cursor
	
	end if
	
	open cath_pci cursor on the catheterizations table
	
	loop
	
	fetch cath_pci into protype, proresult, resultrate, pcicompl, cathdate, exit when cath_pci%notfound
	
	open pci_cursor on the pci and catheterizations tables
	
	loop
	
	fetch pci_cursor into bar, name, siz, pcityp, exit when pci_cursor%notfound
	
	insert into the pci_treatment table values (consid, decisionpci, bar, name, siz, pcityp, protype, proresult, resultrate, pcicompl)
	
	end loop
	
	end loop
	
	close pci_cursor
	
	close cath_pci cursor
	
	/* -------------end---------------*/
	
	end if
	
	end if

Procedure Exec_mod2	end if end if /*--end------------------------------------*/ Send announcement of the previous new case of treatment to other remote hospital by: delete from the announcement table of remote hospital (i.e. erbil) insert into the announcement table of remote erbil hospital values ('case', 'agth', 'duhok') /* agth is the name of the hospital whose sent an announcement */ end

Procedure
 	
Exec_mod3
	/* This procedure updates data from knowledge base part of KB&DB module when any update happens in database part of the same module. For example this procedure deletes all data related to the patient treatment when the status of patient treatment changes from complete to incomplete by receiving E module a message from A&P module of this change */
	
	procedure exec_mod2 with two parameters (consid, treatment)
	
	begin
	
	if treatment not equal 'incomplete' then
	
	update the treatments table by set of column rare_case to 'n' where column d_id equal consid and column how_treat equal treatment and column rare_case equal 'y'
	
	delete from the rare_cases table where column d_id equal consid and column how_treat = treatment
	
	else
	
	/* delete from childs */
	
	delete from the cabg_treatment table where column d_id equal consid
	
	delete from the medical_treatment table where column d_id equal consid
	
	delete from the pci_treatment table where column d_id equal consid
	
	delete from the rare_cases table where column d_id equal consid
	
	/* delete from parent but child to another */
	
	delete from the treatments table where column d_id = consid
	
	delete from the patient_attributes table where column d_id equal consid
	
	/* delete from parent */
	
	delete from the diagnosises table where column d_id equal consid

	end if
	
	end
	
	/* This procedure updates and adds data to knowledge base part in KB&DB module when any update happens in database part of the same module. For example this procedure adds details of surgery and of medical staff who did this surgery when this surgery considered as a rare case after the status of patient treatment has changed to complete*/
	
	procedure exec_mod3 with two parameters (consid, treatment)
	
	begin
	
	  update the treatments table by set of column rare_case to 'y' where column d_id equal consid and column how_treat equal treatment and column rare_case not equal 'y'
	
	  if treatment equal 'medication' then
	
	    open doctor_medical cursor on the doctor_profile and examinations tables
	
	      loop
	
	        fetch doctor_medical into fullname, position, exit when doctor_medical%notfound
	
	        insert into the rare_cases table values (consid, treatment, fullname, position, 'doctor')
	
	      end loop
	
	    close doctor_medical cursor
	
	  else if treatment equal 'pci' then
	
	    open cath_drname cursor on the catheterizations table
	
	      loop
	
	        fetch cath_drname into cathtype, exit when cath_drname%notfound
	
	        if cathtype equal 'ther' or cathtype equal 'diagther' then
	
	          open doctor_pci cursor on the catheterizations and cathstaff tables
	
	            loop
	
	              fetch doctor_pci into member, rolepci, exit when doctor_pci%notfound
	
	              select doctor full name, doctor type into fullnamepci, positionpci from the doctor_profile table where column doctor_id equal member
	
	              select column role_name into rolenamepci from the staffrole table where column role_id equal rolepci
	
	              insert into the rare_cases table values (consid, treatment, fullnamepci, positionpci, rolenamepci)

Procedure
 	
Exec_mod4
 	
Procedure
 	
Exec_mod5
	end loop
	end if
	end loop
	close doctor_pci cursor
	close cath_drname cursor
	else if treatment equal 'surgery' then
	open surgery_drname cursor o the surgery table
	loop
	fetch surgery_drname into opresult, exit when surgery_drname%notfound
	if opresult equal 'successful' then
	open doctor_surgery cursor on the surgerystaff and surgery tables
	loop
	fetch doctor_surgery into membstaff, rolesurg, exit when doctor_surgery%notfound
	select doctor full name, doctor type into fullnamesurg, positionsurg from the doctor_profile table where column doctor_id equal membstaff
	select column role_name into rolenamesurg from the staffrole table where column role_id equal rolesurg
	insert into the rare_cases table values (consid, treatment, fullnamesurg, positionsurg, rolenamesurg)
	end loop
	end if
	end loop
	close doctor_surgery cursor
	close surgery_drname cursor
	end if
	end if
	end if
	end
	
	/* This procedure sends a new announcement of creating the new schedule of physicians in the local hospital to other remote hospitals*/
	procedure exec_mod4
	begin

<table>
<tr>
<td>Procedure

Exec_mod6

Procedure

Exec_mod7</td>
<td>delete from the announcement table of the remote hospital (i.e. erbil)

insert into the announcement table of the remote erbil hospitalvalues ('schedule', 'agth', 'duhok') /* as message of create a new schedule as schedule, name of hospital (agth) and database link (duhok) */

end

/* This procedure sends a new announcement of updating of the statistical information in the local hospital to other remote hospitals, for example, number of patients*/

procedure exec_mod5

begin

delete from the announcement table of the remote hospital (i.e. erbil)

insert into the announcement table of the remote erbil hospital values ('statistic', 'agth', 'duhok') /* as message of updating in the statistical information as statistic, name of hospital (agth) and database link (duhok) */

end

/* This procedure dos a session on the knowledge base part of the remote hospital to create a view on the patient treatment cases done by physicians of remote hospital*/

procedure exec_mod6 with three parameters (notetype, hospitalname, dblink)

begin

    open ann cursor on views available in the knowledge bas of the remote hospital

        loop

            fetch ann into ownerview, viewname, exit when ann%notfound

            execute sql statement of ('create or replace synonym syn_'|| viewname|| dblink||' for '|| ownerview||'.'|| viewname||'@'|| dblink)

        end loop

    close ann

end

/* This procedure dos a session on the database part of the remote hospital to create a view on the physician’s schedules of remote hospital */

procedure exec_mod7 with three parameters (notetype, hospitalname, dblink)</td>
</tr>
</table>

Procedure
 	
Exec_mod8
	begin
	
	    open ann cursor on views available in the database of the remote hospital
	
	        loop
	
	            fetch ann into ownerview, viewname, exit when ann%notfound
	
	            execute sql statement of ('create or replace synonym syn_'|| viewname|| dblink||' for '|| ownerview||'.'|| viewname||'@'|| dblink)
	
	        end loop
	
	    close ann
	
	end
	
	/* This procedure dos a session on the database part of the remote hospital to create a view on the statistical information of the remote hospital */
	
	procedure exec_mod8 with three parameters (notetype, hospitalname, dblink)
	
	begin
	
	    open ann cursor on views available in the database of the remote hospital
	
	        loop
	
	            fetch ann into ownerview, viewname, exit when ann%notfound
	
	            execute sql statement of ('create or replace synonym syn_'|| viewname|| dblink||' for '|| ownerview||'.'|| viewname||'@'|| dblink)
	
	        end loop
	
	    close ann
	
	end

The FHIS Interface Modules Description for User as User Manual

Welcome to the FHIS application as user manual. This description of system topic explains the purpose and functionality of the application. In the beginning, the user must select hospital name in the first page then press Login. In the next page, the user must insert user name and password then Login in order to navigate in the system (see Image_01). After logging in, the application displays a number of tabs. You can load the screen for a particular function by clicking its tab. The following sections describe the contents of each tab.

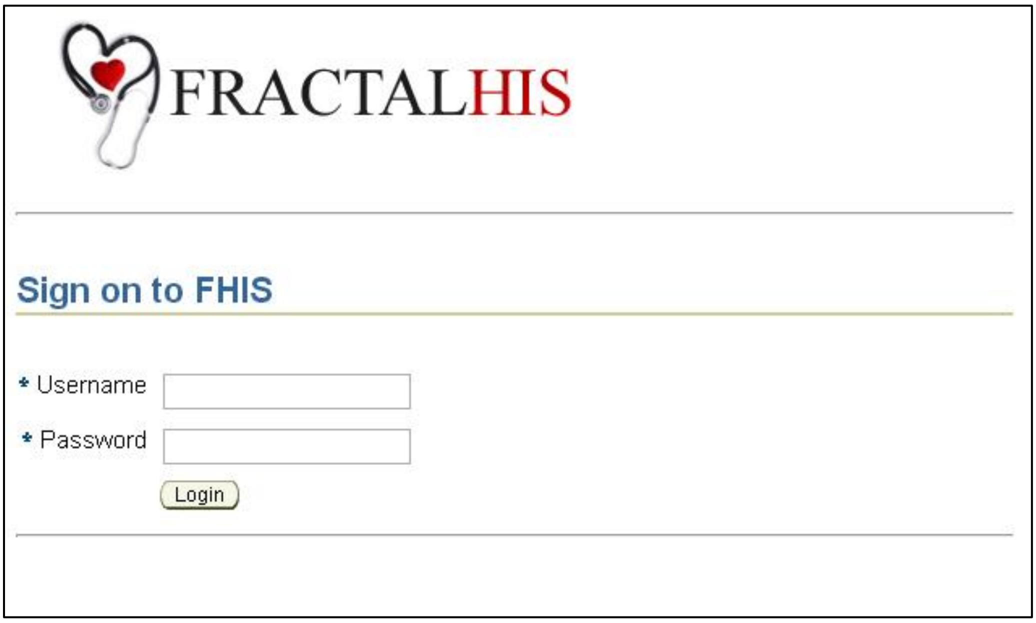


Image_01

Home Tab:

This tab displays the application name & hospital name, and all other taps available for this system (see Image_02).

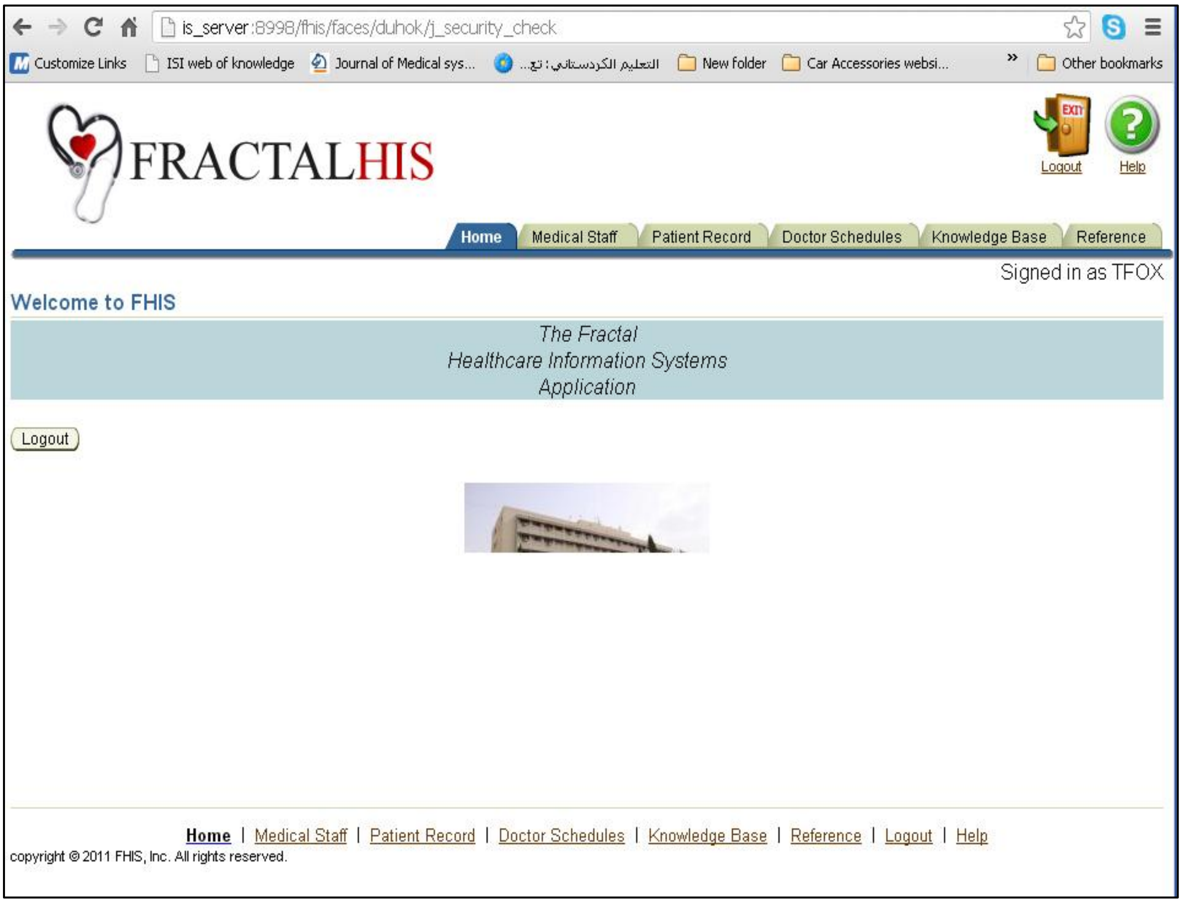


Image_02

Medical Staff Tab:

Select the Medical Staff Tab, as shown in the Image_02. This tab allows you to search for a particular medical staff record. If you have an authorization as manager or administrator, you can also edit medical staff profile information and/or add a new medical staff record.

The search criterias are shown in the following image: (see Image_03)

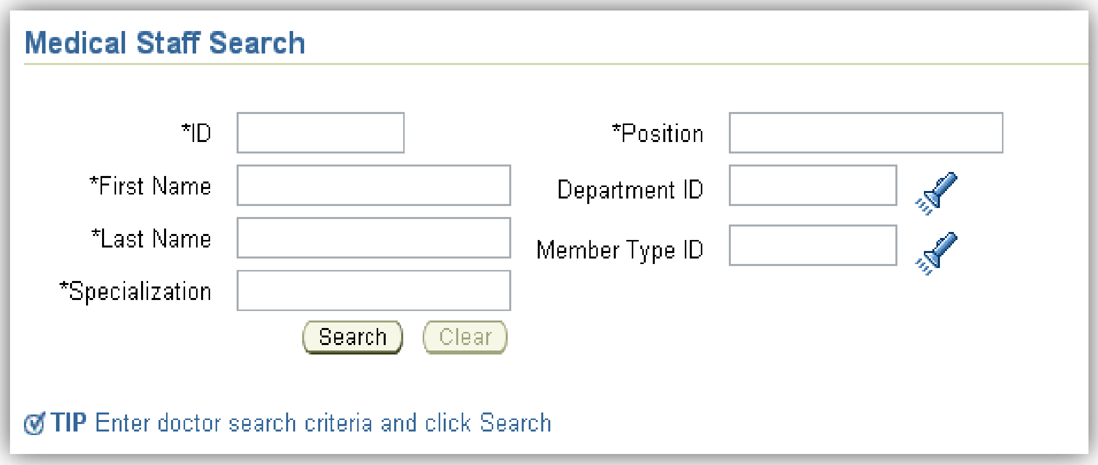


Image_03

Note: after clicking Search button the results table will appear depending on the criterias that have entered. If you want to see all records just leave all text boxes blank and click Search.

Patient Record Tab:

Select the Patient Record Tab, as shown in the Image_02. This tab allows you to search for a particular patient record and view the historical information for the patient. If you have an authorization as manager or administrator, you can also edit patient profile information and/or add a new patient record, as shown in the following steps:

Step 1: The search criterias are shown in the following image: (see Image_04)

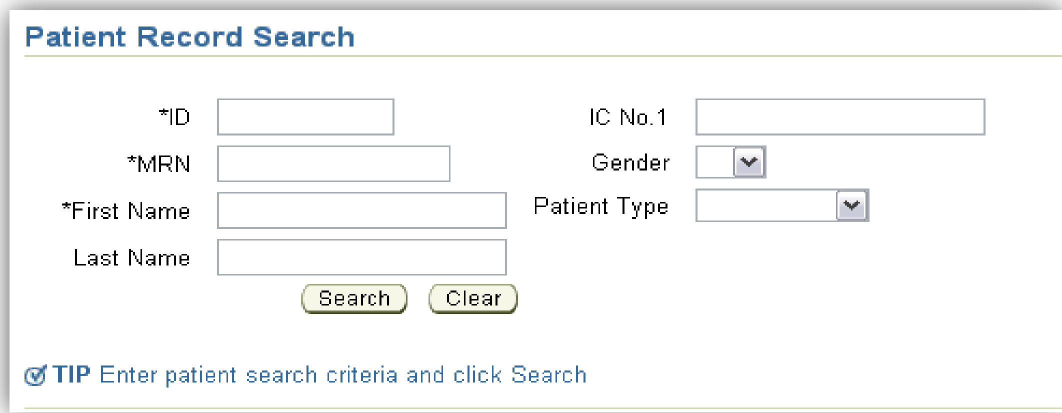


Image_04

Note: after clicking Search button the results table will appear depending on the criterias that have entered. If you want to see all records just leave all text boxes blank and click Search.

Step 2: Then, after click Search button the results table will appear as shown in the following image: (see Image_05)

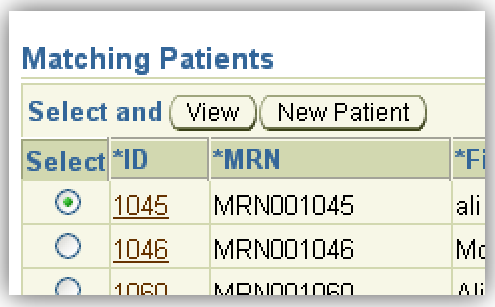


Image_05

Note: if you have not an authorization as manager or administrator, you can't see the New Patient button.

Step 3: Click on the patient ID or select the radio button then click View button in order to see the historical information of patient (i.e. patient details, family history, previous illness, consultation history, patient monitor), as shown in the following image: (see Image_06)

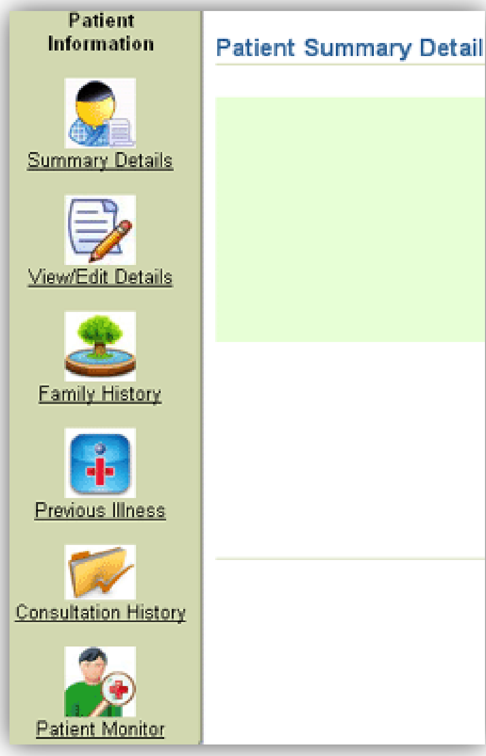


Image_06

Note: if you have not an authorization as manager or administrator, you can't see the View/Edite Details icon.

Step 4: Click on the Consultation History in order to see more information of patient (i.e. Consultation Details, Decisions, Investigations, Diagnosis, treatment), as shown in the image_07 & image_08.

Image_07

Note: In image_07, just click on the consultation date or select the radio button then click on View button in order to see the consultation details, as shown in the image_08.

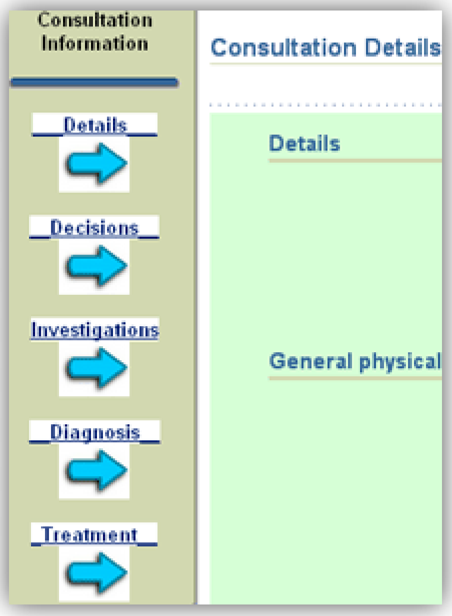


Image_08

In the Image_08, the user can see all details of consultation, decisions, investigations, diagnosis and treatment done for each patient by one physician or group of physicians. The following images show the details of each button in the left side bar of Image_08.

<u>Decisions Button:</u>

Press the Decisions button on the left side bar of Image_08. The decisions have done by a physician on a patient case come out (see Image_09). If you have an authorization, you can also edit decision information and/or add a new decision.

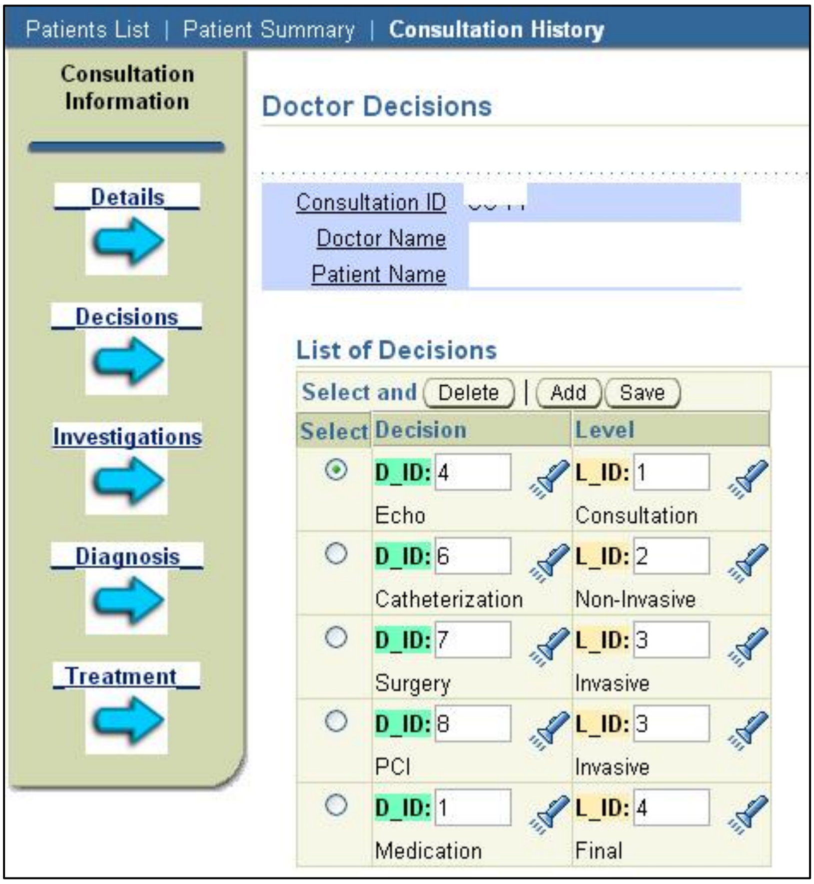


Image_09

Investigations Button:

Press the Investigations button on the left side bar of Image_08. The investigations have done on a patient case come out (see Image_10). If you have an authorization, you can also edit Investigation information and/or add a new Investigation (e.g. Lab investigation, ECG investigation, Echo investigation and Catheterization investigation).

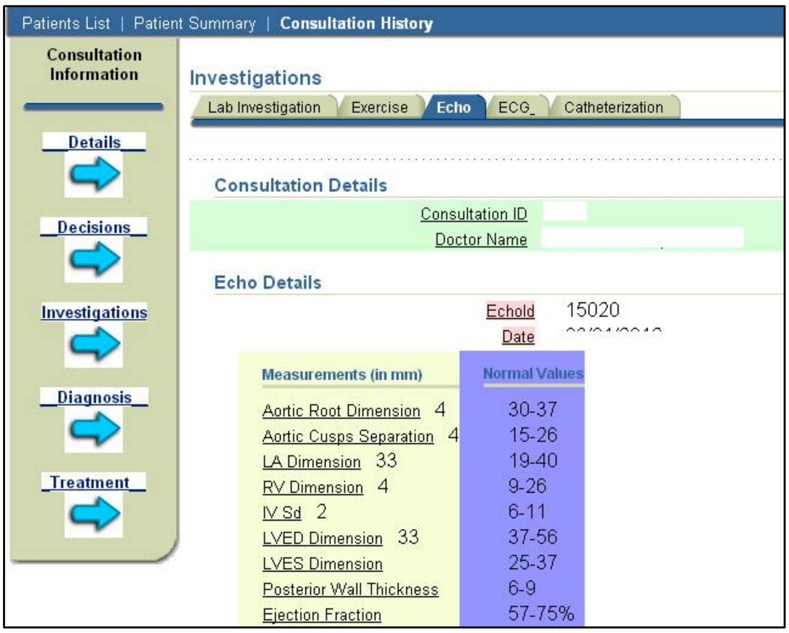


Image_10

Diagnosis Button:

Press the Diagnosis button on the left side bar of Image_08. The first and final diagnoses have done by a physician on a patient case come out (see Image_11). If you have an authorization, you can also edit diagnosis information and/or add a new diagnosis (e.g. first diagnosis and final diagnosis with their dates).

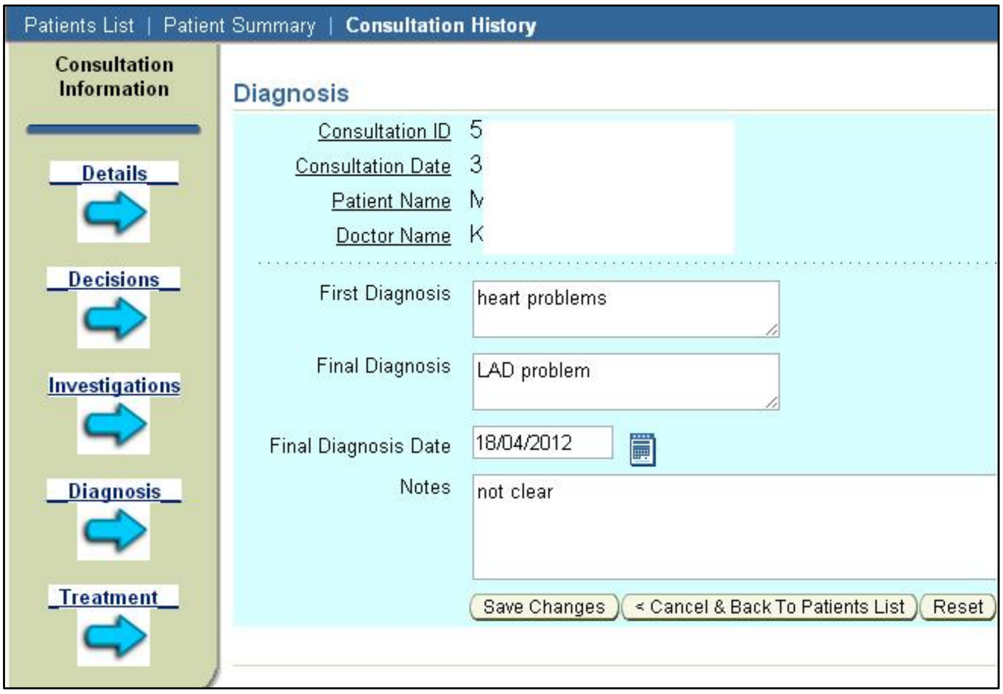


Image_11

Treatment Button:

Press the Treatment button on the left side bar of Image_08. The treatment has done by a physician on a patient case comes out (see Image_12). If you have an authorization, you can also edit treatment information and/or add a new treatment (e.g. Medical treatment, PCI treatment, and Surgery treatment).

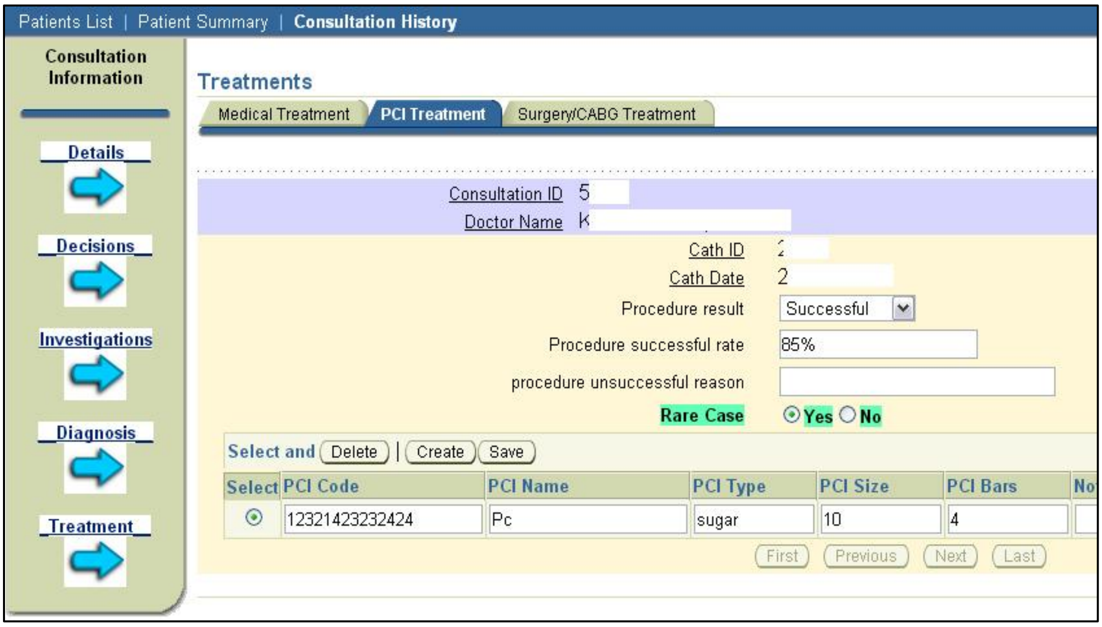


Image_12

Doctor Schedules Tab:

Select the Doctor Schedules tab as shown in the Image_02. This tab allows you to search for a particular schedule of doctors. If you have an authorization as manager or administrator, you can also edit this schedule. You can insert the first date of each month in the text box or leave it blank (for showing all months), then click Search button in order to see doctors' schedule. The example is shown in the Image_13 and Image_14 (result).

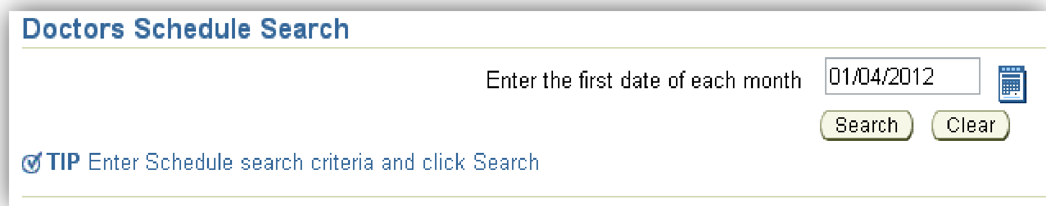


Image_13

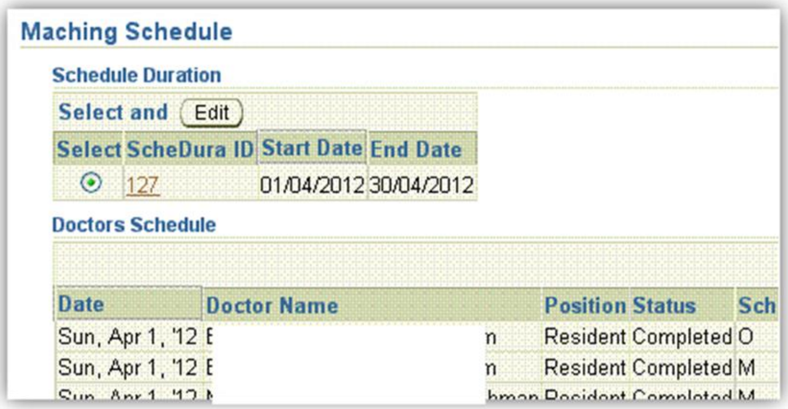


Image_14

Knowledge Base Tab:

Select the Knowledge Base tab as shown in the Image_02. This tab allows you to search for Rare Cases of the patient treatment, Diagnostic & Therapeutic and Statistical Information.
The first page is for Rare Cases. Inter the duration or select show all then click Search button in order to see all rare cases of the patient treatment that have done in the hospital, as shown in the Image_15.

Image_15

Note: In order to see the rare cases of other hospitals, just select the hospital name in the left side bar and follow the same way as mentioned previously.

Select Diagnostic and Therapeutic tab in the page. Then, inter the patient attribute & value and/or diagnosis then click Search button in order to see details of the patient treatment, as shown in the Image_16: (in order to see all cases just leave all text boxes blank and click Search button)

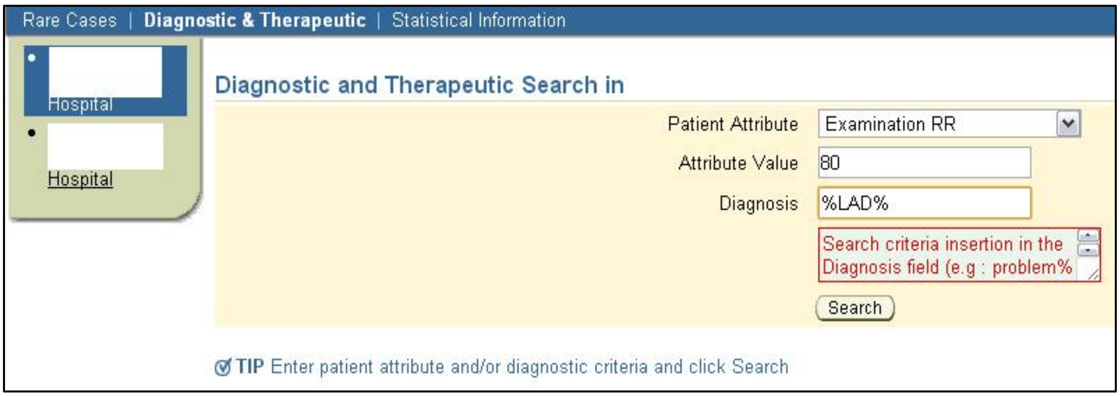


Image_16

Note: In order to see the cases of patient treatment of other hospitals, just select the hospital name in the left side bar and follow the same way as mentioned previously.

Select Statistical Information tab in the page. Then, you can see many charts and diagrams, as shown in Image_17.

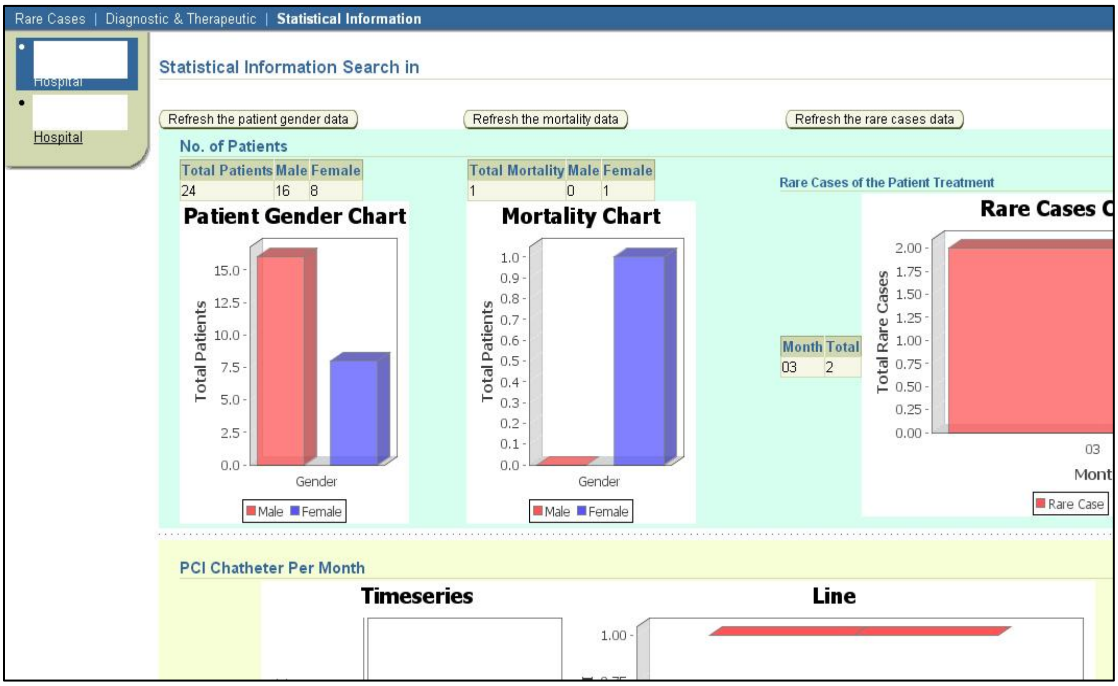


Image_17

Note: In order to see the statistical information of other hospitals, just select the hospital name in the left side bar.

Reference Tab:

Select the Reference tab as shown in the Image_02. This tab contains information available for administrations. It allows them to modify location, department, decision type, schedule type, member type, and indication type records (see Image_18).

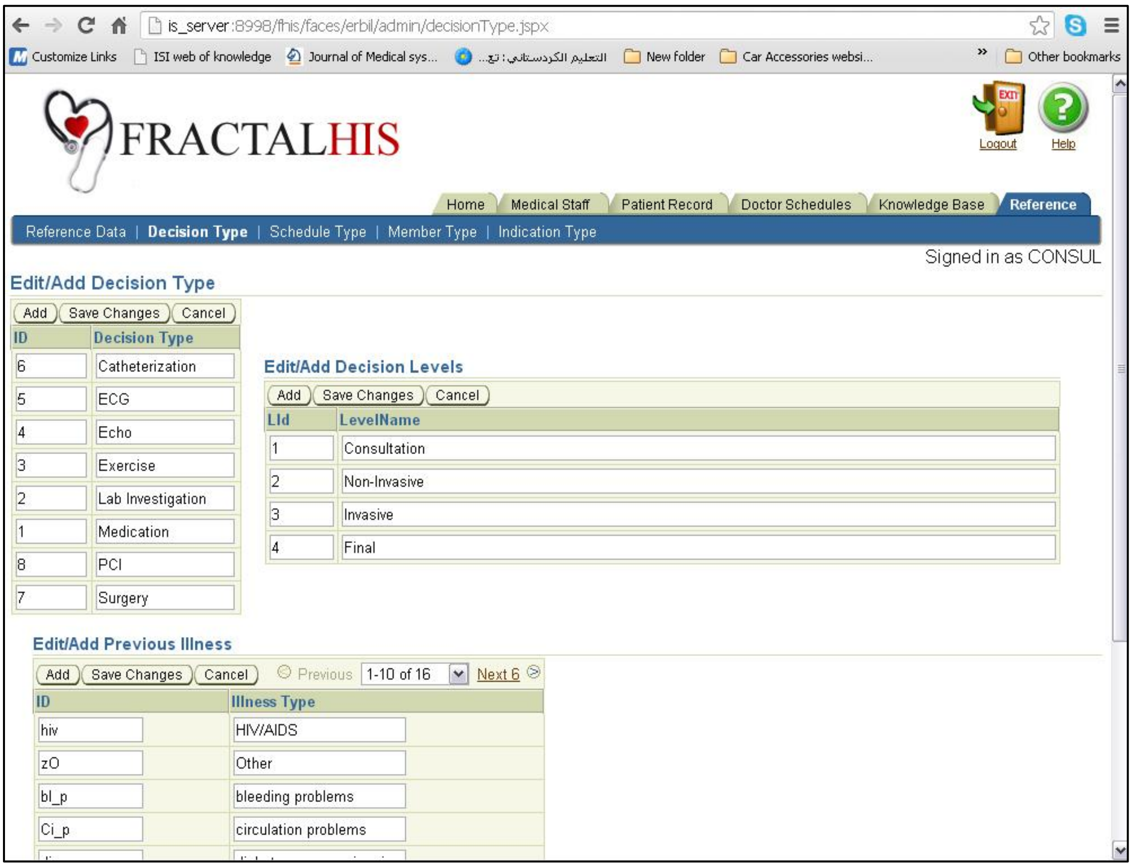


Image_18

Logout Button:

Once the user completes the work and the navigation, he or she can log out by clicking the *Logout* button. This button is available at the top right of each page. It is also available in the left side of home page (see Image_02). Then, after pressing this button (Logout button) the logout page displays a confirmation message with two buttons: *Yes* and *No*. Clicking *Yes* logs the user out of the FHIS and returns the user to the public home page. Clicking *No* (or the *Cancel* button at the top of the page) returns the user to the secure home page of the hospital website (see Image_19).


is_server:8998/fhis/faces/erbil/logout.jspx
Customize Links
ISI web of knowledge
Journal of Medical sys...
Other bookmarks
FRACTALHIS
Cancel
Logout Confirmation
Are you sure you want to log out
Yes
No
Cancel
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Image_19