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A FRAMEWORK FOR DESIGNING AN INFORMATION SYSTEM FOR DOWN SYNDROME PATIENTS

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A FRAMEWORK FOR DESIGNING AN INFORMATION SYSTEM FOR DOWN SYNDROME PATIENTS

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Approval of the Graduate School of Natural and Applied Sciences, Atilim University.

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I certify that this thesis satisfies all the requirements as a thesis for the degree of **Doctor of Philosophy in Modeling and Design of Engineering System, Atilim University.**

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This is to certify that we have read the thesis "A Framework for Designing An Information System For Down Syndrome Patients" submitted by Haitham Latif Hassan AL-TAMEEMI and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

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ABSTRACT

A FRAMEWORK FOR DESIGNING AN INFORMATION SYSTEM FOR DOWN SYNDROME PATIENTS

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PhD in Modeling and Design of Engineering Systems (MODES)

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The possibility of setting up a framework for designing a new system for individuals with Down syndrome was studied. The idea behind this framework is to develop a remote monitoring system called Down Syndrome Information System (DSIS) that will contribute to improve the health status of individuals with Down syndrome, by allocating more resources to information technology. This framework is intended to guide developers to implement the proposed system in the future. The main objective of this thesis is to answer the question of can the proposed framework will be able to support the developers to design a DSIS. In order to answer this question, it is required to find answers to these other questions. 1) Can the proposed system satisfy end user's needs?; 2) Can the proposed system invest in IT in the healthcare field?; 3) Is the proposed system implementable by the developer? 4) What are the advantages between the newly proposed and the current system? The related works were surveyed and it was found that there is a lack in IT investment in health care services for people with Down syndrome. This lack became one of the main motivations for this thesis. In addition, the first three steps of system development life cycle approach (SDLC) will play a big role in setting the methodology of this framework. Questions 1 and 2 were

addressed by the investigations illustrated. As for questions 3 and 4, they were answered by visualizing the proposed system to ensure implementing it.

Limitations of this thesis include; 1) The proposed system is only applied for Down syndrome cases. 2) Using correlations functions as a statistical method to analyze the results of questionnaire form. 3) Using the first three steps of SDLC approach to set this framework. 4) Lastly, there are limitations related to the collections of feedbacks from some of Arabic countries including Iraq, and the dependent on journals and conferences for previous studies.

This thesis will expected to contribute to set this framework as an educational guide for developers to build monitoring system for Down syndrome, build a hybrid system by involving the responsible people of Down syndrome in this system, and enhance the health status of individuals with Down syndrome.

Keywords: Design Framework, Down Syndrome, DSIS, Information Technology, Monitoring System.

ÖZ

DOWN SYNDROME'LU HASTALAR İÇİN BİR BİLGİ SİSTEMİ ÇERÇEVESİ TASARIMI

AL-TAMEEMI, Haitham
Doktora, Mühendislik Sistemlerinin Modellenmesi Ve Tasarımı
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Bu çalışmada Down sendromlu bireyler için yeni bir sistem çerçevesi tasarlanmıştır. Bu çerçevenin arkasındaki fikir, bilgi teknolojisilerine daha fazla kaynak tahsis etmek suretiyle, Down Sendromlu Bilgi Sistemi (DSIS) olarak adlandırılan ve Down sendromlu bireylerin sağlık durumunun iyileştirilmesine katkıda bulunacak bir uzaktan izleme sisteminin geliştirilmesini sağlamaktır. Bu çerçevenin, geliştiricilere önerilen sistemi gelecekte uygulama konusunda rehberlik etmesi amaçlanmaktadır. Bu tezin temel amacı, önerilen çerçevenin geliştiricilerin bir DSIS tasarlamalarını destekleyebileceği sorusuna cevap vermektir. Bu soruyu cevaplamak için, şu soruları yanıtlamak gerekir. 1) Önerilen sistem son kullanıcının ihtiyaçlarını karşılayabilir mi? 2) Önerilen sistem sağlık alanında BT'ye yatırım yapabilir mi? 3) Önerilen sistem geliştirici tarafından uygulanabilir mi? 4) Yeni önerilen ve mevcut sistem arasındaki avantajlar nelerdir? İlgili çalışmalar araştırılmış ve Down Sendromlu insanlar için sağlık hizmetlerinde BT yatırımında bir eksiklik olduğu görülmüştür. Bu eksiklik, bu tezin ana motivasyonlarından biridir. Bunlara ek olarak, Sistem Geliştirme Yaşam Döngüsü yaklaşımının (SGYD) ilk üç adımı bu çerçevenin metodolojisini belirlemede

büyük rol oynamıştır. Soru 1 ve 2, sunulan analizlerde adreslenmiştir. 3. ve 4. sorular ise, uygulamayı sağlamak için önerilen sistemi görselleştirerek yanıtlanmıştır.

Bu tezin sınırlamaları; 1) Önerilen sistem sadece Down sendrom alanında uygulanır. 2) Anket sonuçlarını analiz etmek için istatistiksel metot olarak korelasyon fonksiyonları kullanılmıştır. 3) Bu çerçeveyi tasarlamak için ilk üç SGYD adımı kullanılmıştır. 4) Son olarak, Irak dahil sadece bazı Arap ülkelerinden gelen geri bildirimlerin toplanması ve önceki çalışmalar için dergilere ve konferanslara bağımlı olmakla ilgili kısıtlamalar bulunmaktadır.

Bu tezde sunulan çerçevenin, geliştiricilerin Down sendrom'lu hastalar için bir izleme sistemi oluşturması, Down sendromlu hastalarından sorumlu bireyleri bu sisteme dahil ederek bir melez sistem geliştirilmesi ve Down sendromlu bireylerin sağlık durumunun iyileştirmesi için bir yönlendirme rehberi olarak kullanılması amacıyla katkı sağlaması beklenmektedir.

Anahtar Kelimeler: Tasarım Çerçevesi, Down Sendromu, DSİS, Bilgi Teknolojisi, İzleme Sistemi.

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LIST OF SYMBOLS/ABBREVIATIONS

AAP	American Academy of Pediatrics
AmI	An Ambient Intelligence
ARNP	Advanced Registered Nurse Practitioner
BAN's	Body Area Networks
CAN	Clinical Nurse Specialist
CMMS	Computerized Maintenance Management System
CR	Compression Ratio
DS	Down Syndrome
DSIS	Down Syndrome Information System
ECG	Electrocardiogram
EHR	Electronic Health Record
FHE	Fully Homomorphic Encryption
GPS	Global Positioning System
GSM	Global System for Mobile
HIS	Health Information System
IoT	Internet of Things

IQ	Intelligence Quotient
IT	Information Technology
KMs	Knowledge Management System
LPN	A Licensed Practical Nurse
RFID	Radio Frequency Identification
RMMs	Remote Medical Monitoring system
RN	Registered Nurse
SDLC	System Development Life Cycle
SMS	Short Message Service
SPSS	Statistical Package for the Social Sciences
TMC	Thesis Monitoring Committee
UML	Unified Modeling Language
UWB	Ultra-Wide Band
VCC	Vehicular Cloud Computing
WBAN	Wireless Body Area Networks
WISP	Wireless Internet Service Provider
WSN	Wireless Sensor Network
XMPP	Extensible Messaging and Presence Protocol

CHAPTER 1

INTRODUCTION

In this thesis, the technical possibilities of setting up a framework for designing a special system for people with Down syndrome (DS) was investigated. This framework will contribute to implement a new system that called a Down syndrome information system (DSIS), which could contribute to improve providing healthcare services by invest in Information Technologies (IT). This system will be monitoring health status of individuals with DS and provide a proactive health services.

Therefore, this Chapter will provide a general introduction of this thesis to make the reader familiar with it.

1.1 Problem Statement

DS is an intellectual disability due to defect of certain genes. People with this condition face many challenges that affect in their lifestyle, but one of the biggest problem is that related to their health status [1].

As the technological advancement is continuing unabated, and the huge contribution of the IT on healthcare have caught the attention of many researchers. Many applications such as smart hospitals and remote monitoring system have already been successfully implemented and their benefits are evident [2].

One of the keys to success develop any system is an existing plan in which all the potential components to affect the system are clearly determined [3]. This planning is called the system framework. Therefore, a framework serves as a guide for both, system users and developers. It includes and describe all the objectives, requirements

and activities of the proposed system, as well as the communication channels among various activities [4].

1.2 Purpose and Scope

This thesis revolved around the possibility of using the scientific approach to set up a framework to design a DSIS, which will serve as a guide for the future developers. Therefore, the main purpose of this thesis is directed towards developers to ensure successful development of the proposed system. In addition, this thesis is also aiming for the end users to support them by increasing the efficiency in providing healthcare services.

Furthermore, this thesis revolved around the possibility of increasing investment in healthcare-related IT. In short, the scopes of this thesis are as follows:

1. The healthcare scope aiming to computerize all activities in transferring medical data and design a monitoring system to track health status of people with DS.
2. The IT scope aiming to integrate modern information technologies to be used within the proposed system like medical sensors.
3. The computer science scope aiming to support the developer to design the proposed system by defining all activities and role of actors within the system.
4. The scope of human rights as the international system, which responsible for monitoring individual needs and evaluation of the provision of services for them, especially for individual with disabilities.
5. The education scope as this thesis can be considered as an educational tool for designing other similar systems in the future [5].

1.3 Motivation

The main motivation of this thesis is a real personal story, since the researcher's brother is a person with DS and this thesis aims to ensure develop DSIS to improve his lifestyle and thousands of other who are in a similar position. Therefore, the researcher has been

in direct contact with a DS case and the challenges faced by such people in their daily lives, their integration into community and the difficulties they face as a result of an inadequate healthcare system.

The second motivation is the lack of investment in IT in the healthcare sector to support people with disability who need a responsible person to provide health services.

1.4 Research Question

As a purpose of this thesis, the researcher tries to answer the following main question followed by some secondary ones:

The main question is:

Can the proposed framework will be able to support the developers to design a Down syndrome information system (DSIS)?

This question leads to answer the following:

1. Can the proposed system satisfy the end users?
2. Can the proposed system invest in IT in the healthcare field?
3. Is the proposed system be implementable by the developer?
4. What are the advantages between the proposed system and the current one?

1.5 Software Tools

1. A Google form was used as explained in Chapter 3 to prepare the questionnaire and collect the feedbacks on it.
2. A Statistical Package for the Social Sciences software (SPSS) version 18.0 together with Microsoft Excel 2016 were used in Chapter 3 to analyze answers of the questionnaire.
3. Microsoft Visio 2016 was used in Chapter 4 to prepare all the flow charts, use case diagrams and class diagrams.

1.6 Research Methods

The research methodology was conducted according the outcome of Chapter two, and it consist of three parts.

A. Determine the purpose, scope and methodology of this thesis

Chapter two of this thesis is meant to define the main purpose and scope of the thesis. Therefore, the methodology of this Chapter is as follows.

1. The idea of this thesis started with the researcher who aimed to build a monitoring system for the health status of individuals with disability with a focus on DS.
2. The relevant of literature was surveyed to find information about applications of IT on healthcare and it was concluded that the proposed framework is an optimal factor to build the proposed system.

B. Investigation to define the objectives, requirements, and high level of proposed system

The thesis objectives were defined according to the outcomes of research and analysis on 5 steps in Chapter 3. There are as the follows.

1. A survey of previous studies was conducted to define thesis hypotheses.
2. The hypotheses were tested on a real sample among families who have a member with DS. A cluster sample from some Arabic countries included Iraq was chosen in this step.
3. Results were analyzed to test the hypotheses.
4. These steps lead to the conclusion that the investing in IT in healthcare leads to drastic improvements in this field. In addition, visualize the high level of the proposed system to manage the activities of proposed system, choose a medical sensor to monitor

the health status, made a taxonomy of providing medical services that used to manage provided it by the proposed system.

C. Conceptual design to ensure the system is implementable

To ensure that the proposed system is implementation, the framework scenarios must be visualized according the recommendation of experts by:

1. Define system requirements.
2. Visualize the role of participants by Use Case diagram.
3. Visualize the activities by Class diagram.
4. All steps conducted according to recommendation from thesis monitoring committee (TCM) and developers to ensure its validity and implement the proposed system.

1.7 Obtaining Data

1 As mentioned in section 1.6 above, the questionnaire form was used to collect the data. 151 feedbacks were collected from a cluster sample in some Arabic countries included Iraq. The participants in the proposed questionnaire are families with child with DS.

2 About the interviews in Chapter 3, the experimental and academic experts participated and their views on different issues were taken into account.

3 Finally, two developers contributed in evaluating the capability of implementing this framework and provided some comments and recommendations.

CHAPTER 2

BACKGROUND AND RELATED WORK

As presented in Chapter 1, the main motivation of this thesis is to design a new system for DS patients (section 1.3). However, it is necessary to first establish where and how to start designing the new system.

This chapter aims to answer these questions by performing a survey of related works that will lead to defining the scope, purpose and methodology of this thesis. In addition, this chapter presents a brief background of the study based on the available literature.

2.1. Disability

Disability is an impairment that limits an individual's ability to perform normal life activities or functions that are essential in daily life such as practicing of social and economic activities, or personal health care [6, 7]. Maclachlan and Leslie stated that people with disability are those individuals who need special attention and social support from the world and domestic communities in all their life aspects [8]. The disability Services Act of 1993 in Australia defined the disability as a conglomerate of several impairment [9]:

a) Sensory disability that affects vision or hearing.
b) Neurological disability that has an impact on persons' ability to control their movements for example, cerebral palsy.
c) Physical disability that has an impact on the ability to use upper or lower body.
d) Intellectual disability that creates an impact on a person's judgement and ability to learn and communicate such as DS.

e) Cognitive disability that has an impact on persons' thought processes, personality and memory, such as impairment due to a brain injury.
f) Psychiatric disability that has an impact on a person's emotions, thought processes and behaviour, such as schizophrenia and manic depression.

The levels of disabilities vary from simple to severe. These variations depend on the type and condition of each disability. Therefore, we may observe some disabilities such as visual impairment, which allow the person to interact as semi-normal in the society with the help of some advanced technological. Some other people with disabilities, such as those with intellectual disabilities, require a responsible and highly- dedicated person to play the role of an assistant to support them in the society [9-11].

2.2. Down Syndrome

Down syndrome (DS) is a kind of intellectual disability that is caused by a complex genetic condition [1]. It was first described earlier by John Langdon Down in 17th century, and it has an incidence of 1 out of 400-500 babies born throughout the world. DS limits a patient's ability to live normally [5]. The cause of this condition is an extra chromosome appears in pair 21st. This additional chromosome causes an excessive amount of certain proteins to be formed in human's cells, which in turn disturbs normal growth in the body of the fetus [12, 13]. Individuals with DS will have specific features such as circular face, small nose and mouth and large tongue [13]. DS can be classified into three types of genetic variation as follows: [13]:

1. Trisomy 21, in which all the cells in the body have an extra chromosome 21. Around 94% of people with DS have this condition.
2. Translocation, in which extra chromosome 21 material is attached to another chromosome. Around 4% of people with DS have this condition.
3. Mosaicism, in which only some of the cells have extra chromosome 21 material. Around 2% of people with DS having this condition.

Due to the personal story explained above (section 1.3), DS was chosen to prove the objectives of the proposed framework.

2.3. System Framework

System framework refers to the real or conceptual structure of a system that aims to guide it beneficiaries to use it properly [4]. In computer science, the framework of developing any system is a guide for developers to build the proposed system. It is often presented as interconnected layers to make it understandable by beneficiaries [14]. Despite the importance of the framework for developing any system, there is no predetermined conceptual rules for setting a framework in information system fields, it can be determined throughout the objectives of the system. In addition, developing the framework involves some difficulties in the selection of techniques that are used and the general routine of the system. Therefore, some basic principles to eliminate difficulties of setting a framework are [15, 16]:

1. Global consistency of the proposed system. As it is well known, any system consists of various independent and incompatible sections. Therefore, the proposed framework must operate as an integrated system that connects all system's sections.
2. Generality of the proposed system. It means that the framework must be aimed at building a new system and extend in the future to cover more than one field, or to be used in general and not limited to a specific category.
3. Simplicity in applying and using the proposed system. This feature helps the developers to design the proposed system with less error and far from complexity. In addition, it also generalizes the proposed system for its usefulness and the ease of use by the beneficiaries.
4. Directly specifies the objectives of the proposed system.
5. Scalability of the proposed system to be updated according to the new advancements of technologies.

2.4. Health Information System

Health Information System (HIS) means the investment of IT to improve health care services. It consists of all activities of collecting, storing, retrieving, and managing all medical data, in addition making decision about health status of individuals [17].

Electronic Health Record (EHR) is considered the backbone of the HIS as they contain personal information of patients, including diagnoses, medical laboratory tests and analyses, physicians' recommendation, and so on [18, 19].

Therefore, main activities of HIS are [20]:

1. Manage patients' activities by scheduling patients' movement within hospitals.
2. Manage the processes of all health facilities by computerizing them.
3. The Integration with EHR to enhance the provision of health services.
4. Make strong connections between health facilities to ensure a full control and integration of health services among all healthcare departments.
5. Set an optimal strategy to manage healthcare services.

2.5. Development Information System

Development Information system is an overall process to design and implement the information system application within the organization. In fact, it involves a number of steps to identify a certain organizational problem and choose the most efficient design to solve it and meet user requirements. In other words, it studies the feasibility of all related factors to ensure an efficient implementation of the new system. One of the most famous approaches is called System Development Life Cycle (SDLC), which employs multistep and iterative process as follows [3].

1. The first step in developing any system is investigation. In this step, the system problems will defined by study the feasibility of all factors that affect of the system.
2. Analysis step starts after defining system problems and it aims to define the purpose of the new system.
3. Designing the proposed system is the third step of system development. In this step, the architecture of new system will be recognized according on the visualization of the designer.

4. Implementation or sometimes called coding starts once the design is ready for developers. In addition, the new system must be applied on the real sample to test it.
5. Maintenance step is important to ensure the system works. In addition, to make sure the system is updated according to the needs of the time.

2.6. Related Work

As it is well known, IT has a huge potential to transform all the fields of life, and one of them is healthcare. In a research study, it was established that using an interactive web site to exchange information between DS patients and medical practitioners, strengthened their connection and lead to better care [21]. The research presented a project called The DS Consortium Registry (DSConnect), which uses the online-database provided by The US National Institutes of Health [22] to allow sharing secure information among people with DS through their parents and caregivers. In addition, the database allows specialists to get the latest research results on DS. This database is a good resource of information on DS cases that allows improvement on their disease diagnoses.

IT can support health care system through medical applications for people with special needs. A study conducted by Vergara et al. shows the role of IT to support people with disability and recommends using technical tools as a guide for them, such as smart phones and mobile health cloud application for visually impaired people [23]. These tools helps them to walk autonomously, and at the same time allows their parents to monitor them by detecting their spatial position. IT is not limited to only supporting healthcare through medical applications but, it also supports the requirements of health accessories. For example, in Germany, technological advancements are used for navigation of mobile robots to establish an intelligent vehicle for home care services and hospitals. These intelligent vehicles are used to supply and dispose patients' meals, laundry, waste, etc. [24].

Supporting people with DS by engaging them in activities within the society, makes them contribute to the society and give them a positive self-satisfying feeling of

belonging. Nevertheless, this still a big challenge for them and their parents. Therefore, the government of United State developed an employment information system called Ticket-to-Work to support people with DS by help them finding jobs according to their special conditions [25].

It is important to diagnose DS infants early in order to better address their health problems such as heart defects. In developing countries, clinical observations are used to diagnose infants with DS according to facial features, but in developed countries, chromosome analysis called karyotype test is used for the same purpose [26]. Recently, ITs has started to be utilized to determine this condition as soon as the child is born based on face recognition algorithms using either a digital image or a video frame [27-30]. In addition, image processing has a role in healthcare field. For example, a novel wound image analysis system has been developed for persons who have foot ulcers. This system is operable on Android smartphones to detect the condition based on previous images used to training algorithm. It starts by captured a photo off the injury and applies an accelerated mean-shift-based algorithm to make a segmentation of the image. It then analyzes the image according of its features and the changes on color. Among many benefits, the system is very effective in reducing the medical cost of the condition [31, 32].

Due to increasing number of healthcare services and their cost, this sector became one of most challenging problems for all concerned governments. Thus, developed countries are planning to use new strategies to utilize the economic resources efficiently. Investments in IT in healthcare help in improving the sector by improving the diagnosis of diseases earlier and in a more effective way. For example, smartphone applications can be used to monitor the physiological status of patients [33-35].

MyPace is is a mobile application developed for individuals with obesity. It helps patients to lose weight by keeping track and helping in controlling their eating behavior of individuals. This application is considered as an integrated platform, which works by making connections among individuals and dietitians to provide customized advice in real-time [36].

An Ambient Intelligence (AmI) technique in Healthcare helps providing healthcare services by monitoring the health status of elder people and those with various medical conditions. This system helps to connect people with all health facilities and physicians through a private network, and it can exchange medical data and recommendations between them through medical sensors [37]. Figure 2.1 shows how AmI system works.

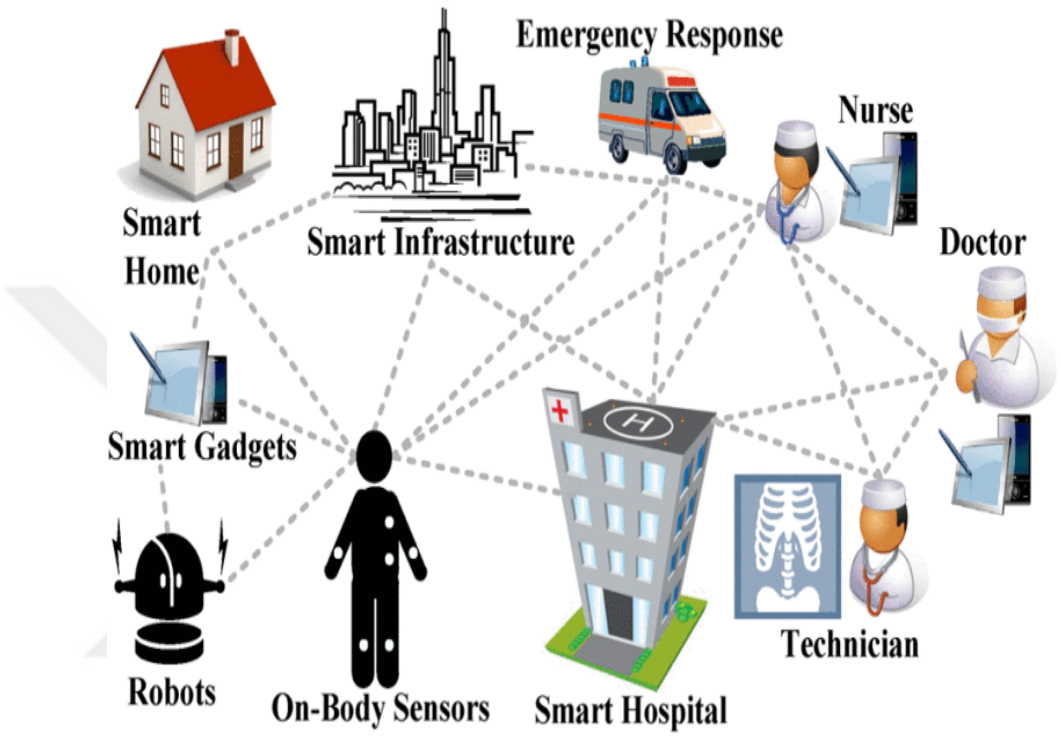

Figure 2.1 Chart of Ambient Intelligence System [37]

Paying money is one of the challenges of people with DS to live independently. Poseidon project is an interactive application aiming to help people with DS to be more independent by training them to pay money. This application uses an interactive interface with sensors under the face of the project table. The specialists patients' parents recommend making this system more flexibility in the future in order to get optimal results by adding more advanced personalization options [38]. Figure 2.2 shows the practice of Poseidon project, which proves the role of IT in enhancing the life style of people with DS.

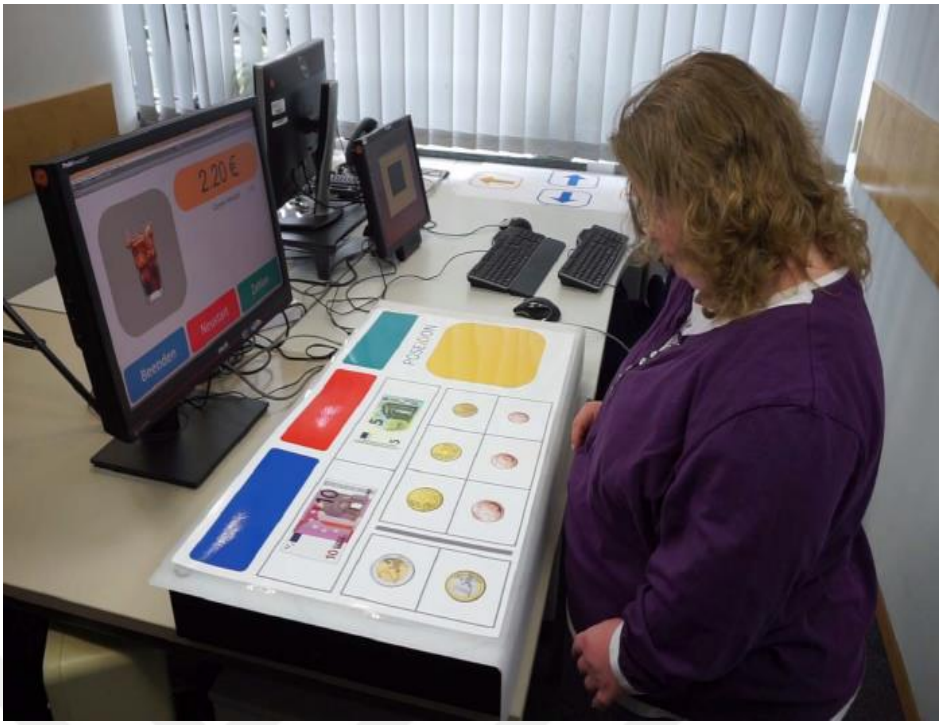

Figure 2.2 Money Handling Training [38]

In developing countries including Iraq, there are many studies about the role of IT in healthcare [39, 40]. They are faced some challenges on applying e-government, one of these challenges is to depend on EHR's to exchange medical records among medical facilities and patients [41, 42]. Therefore, the initial steps required are to generate an electronic health system used for transferring, storing, and retrieving the medical data electronically [41, 42]. Previous articles have proven the role of EHR in enhancing healthcare services by decreasing medical cost, eliminating medication errors, ensuring patients' privacy, and increasing patient's satisfaction. In addition, they also showed improved management of medical facilities [43, 44].

In Papua New Guinea, the old medical system was based on manually storing and retrieving the medical records of the patients. However, the new system start by making an investigation of medical data of patients and is then followed by analysing these data to provide recommendation about the optimal healthcare services that satisfied patients' needs. One of the important recommendations of the designers is capturing the data electronically, which has contributed in building the foundations of an optimal health information system in that country [45].

Utilization of IT in various applications on health care and the widespread use of ICT has played a big role in improving the quality of individuals Life's [46]. Knowledge Management System (KMs) is a kind of IT system used in health scope and improving all activities of hospital. For example, a good diagnosis has an important role in providing optimal healthcare services, and defects in it leads to wrong medical treatment which is at best useless, and at worst life threatening [47]. Another example, UpTo Date system was the product of a retrospective study in Japan to estimate the effectiveness of applying computerized system in order to reduce diagnostic errors. This system works according to the principles of KMs by comparing results with the regular method of diagnosis and using a multivariate logistic regression analysis to provide an effective diagnosis for the patient [48].

The evolution of any society depends on its development of enterprises, and the IT has been playing a major role in the development process, especially when integrated with other technologies such as sensors. This integration has a great impact on development of modern infrastructures such as smart hospitals, cities and so on. In addition, the Internet of Things (IoT) is one of the latest information concepts that has contributed to integrate the world electronically. It integrates various applications and devices in cloud architecture and works to provide services extremely efficiently in real-time. IoT consists of many devices including sensors that work under an information system to collect and analyze data, and make decisions accordingly. IoT has an immense role in the development of modern systems like smart environment and e-health [49, 50].

With the advancement of IT emerged the so-called Remote Medical Monitoring system (RMMs). It is also known as remote patient, healthcare monitoring systems or telemedicine [51, 52]. The RMMs consists of both hardware and software that contacts with both, the end user (patients) and physicians [53]. RMMs components (computer systems, data storage devices, network, and medical sensors to capture vital signals) are integrated to exchange medical data and make health decisions electronically [51]. The goals of RMMs are accuracy, prediction of health-risk, low cost treatment, health-services in the real-time and providing distance education in health sector [54, 55]. RMMs started to provide health services for individuals with chronic diseases, and

monitor them to determine critical cases. For example, Jurik and his partner described this system in three layers (Figure 2.3 shows the architecture of RMMs) [56]:

a) The first layer contains a set of medical sensors that are used to transmit vital signals to the medical center via internet, global system for mobile (GSM) or any communication means.

b) The second layer is the data hub that is responsible for storing medical signals and analyze them to identify emergency cases before sending to the medical center

c) The third layer is the medical center or the medical network that is responsible for providing medical services to emergency cases, like hospital.

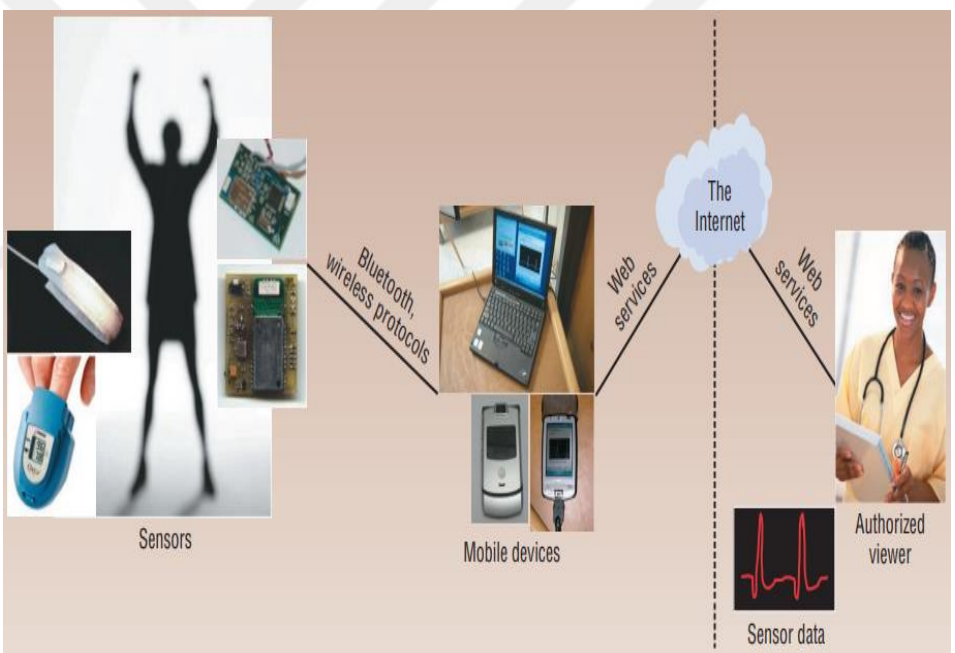

Figure 2.3 The Architecture of RMMs [56]

Healthcare activities works effectively when high quality data are available. Gaynor and his partner presented a framework for integrating data by using sensors and radio frequency identification (RFID) card into IT applications, with the aim of improving health care services. This framework consists of a set of decision making technologies (sensing ability and processing power) and architectural design (such as mobility,

relationship among sensors and main stations, filtering and managing data). This framework has contributed to the design of healthcare systems with accurate data [57].

System thinking is one of most important activities in developing any system to analyze and identify system problems. It consider a disciplined approach to determine system problems more clearly and accurately, by studying all the features and determine the reasons that affect its workings [3]. In healthcare field, the cooperation of system's engineers and healthcare professionals leads to improvements in the field and achieves value, safety, accessibility and satisfaction for the patients who need healthcare services [58].

The SDLC for designing health system has proven the capability and reliability of health care system that is based on information system by its success in identifying problems in old system, as well as its clearly defined objectives. In addition, this approach was able to present a conceptual design of the proposed system before starting to implement it, and allowing the maintainers to update it according to the latest technology to satisfy user needs [59]. Regarding the aspect of user satisfaction, a previous study in Thailand using a first aid mobile application for critical cases showed the willingness of people to rely on the IT [60].

The feasibility of IT to improve the life style of people with DS was also proved from a personal perspective, as the author's brother who has DS was able to learn the names and flags of more countries by using a special mobile application. Therefore, attempts to improve the IT infrastructure on this field by more research and investment is necessary to increase people's awareness to its benefits.

As a conclusion, IT will have an important role in improving all fields of life including healthcare. However, transferring and exchanging IT skills and knowledge is still a big challenge. The most challenging aspect is the planning to ensure a successful and continuous working process. Therefore, the purpose and scope of this thesis is to setup a framework for designing a new system for people with disability, as a first step to ensure development of the proposed system that works continuously and feasibly (as mentioned in section 1.2 above).

As it has been shown throughout this chapter, IT has an essential role in enhancing the development of any system through the modern technologies, and it is playing a critical role to increase the competitiveness of organizations by providing the optimal services with fewer errors [61]. One of the biggest challenges is how to manage activities in order to increase competitiveness and satisfy all beneficiaries' needs. Therefore, setting a framework for development can ensure optimal management of all activities of the proposed system [62]. The most challenging part of setting a framework is the difficulty to understand the information system that is used in an organization. This is caused by the lack of alignment with the old system's strategies or objectives [63]. For example, in Indonesia, the framework for development of a new system for wetland started by determining the problems of farmland. That was followed by analyzing the historical use of these lands and available technologies, and finally optimizing these technologies for current use [64]. In health care field, setting up a framework was enhance and develop strategies to provide health care services through the identification and the analyzation of the current problems in addition to integration of all activities that help in management of the services provided by it [65].

The success of any system depends heavily on its continuity, in other words, the consistency of the end user in using the system [66]. Therefore, the good planning and studying all factors of the system can help to set up an optimal framework. Such framework ensures to build any proposed system and ensure successful execution and consistence utilization by end users [67]. For developers, the framework serves as a guide through the documentation of all processes and activities of the proposed system [68]. One of the important advantages of documentation is working as an interface among developers at all levels, which in turn helps to understand activities and approaches of the system that leads to identify its weakness [69]. Documentation can be classified into two groups [70]:

a) Process documentation, which explains all process, including scheduling and plans, and estimates their quality of these.

b) Product documentation, which explains the products of a system based on the opinion of the develop team.

A study conducted in [71], a framework to improve and integrate health care services for smart hospitals based on pervasive computing environment on Unified Modeling Language (UML) was proposed. Another study in [72], a new system for healthcare services was developed and approved according to the conceptual framework that works as a guide for developers to describe, implement and evaluate to ensure end user satisfaction. In Nairobi, an investigation showed that the hospitals managed and working without any communications among them suffer health care services interruption. However, the new framework that implements patient e-referral improved the communication and thus, led to integrated health care service [73].

System framework helps to define all processes and activities within it, by dividing the system into levels, such as hardware and software. For example, a conceptual framework to improve the safety system was setup to protect people at risk while walking. This framework was setup in three levels:

a) Theoretical level: to determine indicators of the project like safety-based indicators.

b) Hardware level: to determine the hardware needed for project's success, like sensors.

c) Software level: to discuss with software designers the way to succeed.

This framework is used as a guide for other researchers to develop new systems, as well as updating them continuously [74].

2.7. Chapter Discussion and Conclusion

The results of previous studies show the following:

1. Information technology and people with Down syndrome

As presented before, invest on IT leads to improved life style of people in all aspects, including the healthcare sector. For example, smartphone applications have contributed in monitoring physiological status of patients using medical sensors. However, services in helping people with

disability such as DS are still lacking. It is noticeable that the role of IT are limited when it comes to supporting the education of people with DS, and support families by providing some information about them. The current monitoring system is not suitable for them due to their medical condition since it is limited to the use of only the concerned patient. Therefore, following the motives of the thesis mention in Section 1.3, this Chapter aims to choose the scientific strategies to build a monitoring system for individuals with DS that works on multiple scopes (as mentioned in section 1.2), as follows.

a) Healthcare scope as the administrator for providing healthcare services.
b) IT scope by developing and using modern technologies that work within the proposed system like medical sensors.
c) The scope of human rights as the system is responsible for monitoring individual needs and evaluate services provided to them, especially for individual with disabilities.

2. Framework for implementable and continuous system design

As shown here, the system framework contributes to building a system that satisfies all participants, including the end users. In addition, it contributes to ensuring the implementation of this system and use it continuously to describe and visualize the role of all participants within it, the system requirements and activities that achieve the objectives set at the beginning. Therefore, investigation is considered the first step of setting a framework for system design, which contributes to define system problems, problems of end users, and studying the feasibility of all factors that affect the development of the proposed system, such as the technical feasibility. The second step is describe how this system work by define all activities, participants, and visualize them by using a UML diagrams, to support the developers to implement the system.

Therefore, with the motives of the thesis that mention in section 1.3, and scopes in previous point, the main purpose of this thesis is to set a framework to ensure the implementation of a new system for individuals with DS (as mentioned in section 1.2). This system will be working for monitoring the health status of individuals with DS by using medical sensors. In addition, this step will contribute to extend the thesis scopes to computer science and education to support all developers to design any similar system.

In conclusion, this chapter contributed in define the purpose of this thesis by setting a framework for design a DSIS. This purpose will support the developers to implement the proposed system.

In addition, its methodology relies on choosing the first three steps of SDLC, i.e., investigation, analysis, and conceptual design, in setting up the framework.

Figure 2.4 below, shows the methodology of this thesis

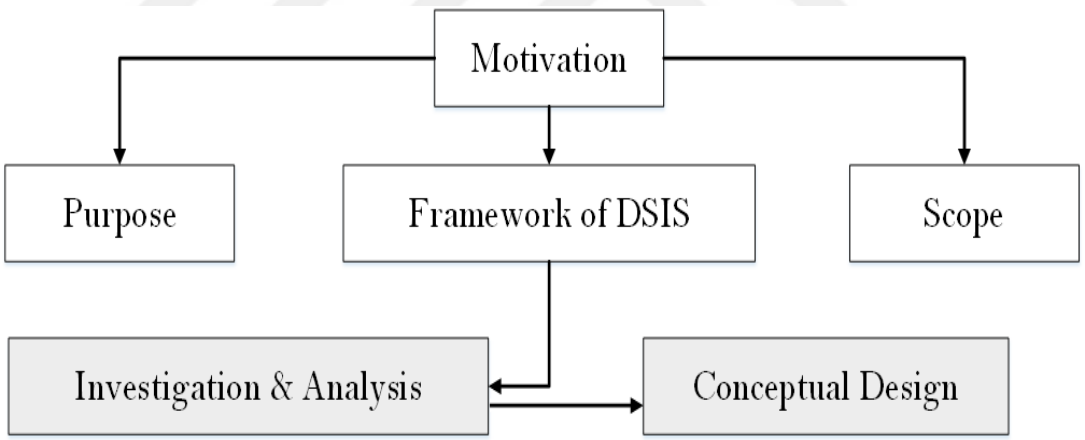

Figure 2.4 Thesis Methodology

CHAPTER 3

INVESTIGATION AND ANALYSIS OF DSIS

According to the thesis methodology that has been presented in section 2.7, the first steps of the proposed framework are investigation and analysis. These steps aim to study the processes of the system in order to understand the experience of all participants within it, as well as to study the feasibility of IT in health field, which will contribute in defining all factors that affect the system, which leads to determine how system will works to decrease these factors.

Therefore, this Chapter will describe the investigation that contributes to [75]:

1. Defining the most common health problems for people with DS.
2. Study the feasibility of current technologies and way in which the might contribute to the design of the proposed system.
3. Clearly define the needs of the end user.
4. Define the high-level structure of proposed system.

The methodology of these steps is based on the scientific method that involves 5 steps as follows [76, 77]:

1. Observation
2. Construct hypotheses
3. Perform experiments
4. Analyze of experiment
5. Discussion and Conclusion.

The following paragraphs will provide detailed explanation on investigation and analysis steps. Figure 3.1 shows the proposed methodology of investigation and analysis of DSIS.

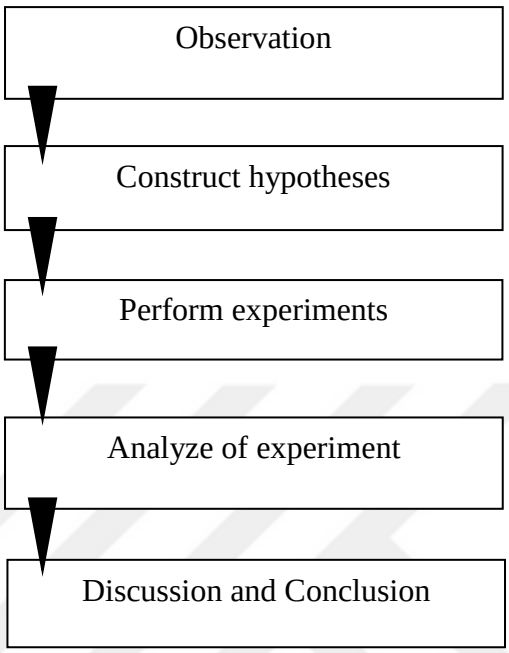

Figure 3.1 The Proposal Approach of Investigation and Analysis of DSIS

3.1. Observation

The first step of any investigation is to conduct a survey covering the most common health problems of individuals with DS and study the feasibility of investing on IT in health field.

3.1.1 Health-Problems of Down Syndrome

Healthcare sector is defined by all public and private institutions that provide healthcare services. It includes all hospitals (public and private), clinics, pharmacies, and human resources (doctors, nurses, medical engineers, technicians, researchers, etc.). WONCA is a European organization which has formulated a statement to set the role of the general practitioners and family doctors in society for providing the core care for all people irrespective of age, sex, and illness type. In addition to their role in family, community, and cultural issues [78]. On the other hand, Surgeon General Koop

identified the specific objectives of individuals with disability in a conference in 1989. These objectives aim to ensure the provision of health-services by early diagnosis of diseases [79].

As mentioned in section 2.2, DS is a genetic condition, so there is no specific treatment for it and all medical services provided are based on physical and intellectual needs of the patients. People with DS have a number of health problems, some of which need an immediate care, and others continuous follow up [80]. Guralnick shows that earlier intervention for people with DS helps to enhance their health-status [81, 82]. In addition, supporting individuals with DS by some health programs can contribute to enhancement of their lifestyle. In United States, fitness and health education programs can help to improve disabled people's general health status [83]. However, these medical services until now do not meet the ambitions of individuals with DS, Williams et al., made a survey for 124 children with DS in USA, and they concluded they have maltreatment risks according to the standards of among American Academy of Pediatrics (AAP) [84]. The Department for Child Protection and Family Support identified disabled children with maltreatment in Western Australia between 1990 and 2010. This project collected and linked all medical data electronically and concluded that individuals with DS are facing continuous maltreatment. Therefore, they recommended supporting them by increasing awareness in society, communities and families by some community awareness lectures [85].

In the following paragraphs, the most common health-related-problems for people with DS will be summarized:

A. Cognitive Deficit

Cognitive deficit describes an individual's weakness in mental processes involved in dealing with information in the society. Intelligence Quotient (IQ) is a standardized intelligence test used to measure the cognitive deficit and the normal measure is equal to or greater than 70. IQ test for person with DS in the best case is less than 70, which leads to limited abilities in decision-making, speaking and memorizing [80, 86].

B. Hearing Loss

Hearing loss is one of the most popular diseases facing DS patients as it occurs in around 75% of them for different reasons [80, 87]. This condition can lead to difficulties in developing language for them [88].

For this reason, the physicians recommend retrying the auditory testing every two years for DS patients by using this test as a measure [89, 90]. For example, the organizers of Special Olympics Games in Germany (2004) and Japan (2005) used special healthy-hearing programs to control the hearing-status of Athletes and only 60% of participants passed this test [91, 92].

C. Vision Diseases

Vision impairments of DS patients keep increasing with age. Although this medical condition is widespread for more than 60% of people with DS [80] (like cataracts [93]). Medical interventions such as glasses and eye-surgery has greatly contributed to improvement in their vision status [80].

Many previous studies have proven the correlation of DS and eye diseases. Haargaard et al. presented an article about the DS and the early cataract and estimated that about 1.4% of them need surgery to recover their eyesight [94].

Moreover, the AAP recommends vision exams especially for infants by a pediatric eye specialist, and redoing the checkup every two years [80].

D. Obstructive Sleep Apnea

Sleep is an indicator of our health, therefore guaranteeing comfortable and enough sleep contributes to eliminating many health problems. For individuals with DS, Sleep Apnea is a kind of respiratory diseases that occurs in up to 50% of them and increasing by age [80]. In addition, it affect their behavior and ability to learning in addition to causing health

problems like heart failure [95]. The sleep study (Polysomnography) helps to diagnose and estimate the sleep status of individuals by collecting the related data during sleep such as oxygen uptake [96-98].

Therefore, physicians recommend continuously monitoring people with DS, especially if they have abnormal physical features, and repeating these tests every two years [80].

E. Heart Defects

One of the most difficult health problems of individuals with DS are heart defects. This condition can cause death if not diagnosed earlier [99]. Therefore, the AAP recommends making the intervention and diagnosis immediately after birth by using an echocardiogram [80]. This condition can occur in around 50% of people with DS with different types [80]. For example, in one condition, a mitral valve prolapses effects on 57% of people with DS and needs continuous treatment and following up [87]. In another example from Saudi Arabia, between the years 2001- 2014, atrial septal defect was found in around 33.5% of people with DS [100]. In Turkey, also heart defect is one of the critical and widely spread diseases among people with DS as is found in around 72% of them [101].

In addition, the previous article showed the relationship between this condition and other health problems. For example, in Brazil, a study showed a relationship between DS and severe infections among children [102]. In addition, a certain heart defect has a relationship with snoring and sleep apnea and it needs continuous monitoring [103].

For these reasons, the physicians recommend a comprehensive test if the patient has one kind of heart defects [102, 103] as well as earlier and continuous intervention to keep the condition under control [81, 82].

F. Digestive Diseases

This is one of the most common health problems for individuals with DS with an incidence of about 12% of them [80]. Sometimes, this disease cause blockage in stomach and intestines and the patient needs surgery to recover from it [104]. In addition, swallowing difficulties and physical deformities of the oral cavity such as long tongue and poorer mouth's muscle can contribute to further worsening of the symptoms [105]. In addition, there is a high prevalence of Gastroesophageal reflux disease (GERD), also one of the common digestive problem that face DS patients with about 12% incidence, so monitoring this disease especially in the new-born can contributed to early diagnosis and avoiding much of the latter symptoms [106, 99].

G. Dental and Periodontal Disease

Dental problems and other related complications in periodontal is quite common in individuals with DS [87]. Because of the physical features of people with DS, this condition may become very disturbing for the patients and lead to loss of teeth [107]. Therefore, dentists recommend continuous checkups every 6 months [87].

H. Thyroid Gland Diseases

Thyroid gland is one of the largest endocrine glands and it is responsible for secretion of two important hormones; Thyroxine T4 and Triiodothyronine T3. These hormones have a direct effect on essential functions of the body like growth, development and metabolism, among many others [108]. Thyroid hormone abnormalities affect 4-18% of individuals with DS and among the most common conditions congenital hypothyroidism and hyperthyroidism [80, 109].

Melinda et al. used retrospective records of individuals with DS to estimate the thyroid abnormalities and concluded that the condition can adversely

affect all people including those with DS in same percentage without showing any relation to gender or obesity [110].

Finally, specialists recommend checking the thyroid-stimulating hormone levels especially for babies and annually [80, 110]. Moreover, a correlation between this condition and heart disease has been reported by another study [111].

I. Chronic Diseases

Chronic diseases for individuals with DS are common but their incidence is low. For example, DS patients often have diabetes, but there are no medical recommendations about for it [87]. Another example of chronic diseases is that of Alzheimer that appears in about 80% DS patients and leads to development of dementia [112]. As a result, the Committee on Genetics of the AAP recommends continuous tracking of this health problem in adulthood. This tracking starts by carefully observing changes, identifying loss of certain functions, monitoring decreases of IQ test, keeping careful historical records of the patient. In addition, they recommend repetition of the IQ test, especially for those who are over 40 years old [84].

J. Blood Disease

It is a common health-problem for individuals with DS throughout their lives, with an incidence 10 times more than normal people. Leukemia, anemia, and polycythemia are the most common blood disorder for them. Therefore, physicians recommend blood testing in an annual basis for DS patients [80, 113].

K. Infections

Individuals with DS are 12 times more prone to infections than the general population.

Therefore, physicians recommend continuous monitoring for them to provide quickened effective treatment [114].

L. Obesity

Obesity is one of the most common problems for individuals with DS. It appears in around 45-79% for male, and 56-96% for females. An unstable dieting (abnormal eating behavior), as well as unstable metabolic rate, hypothyroidism, low exercise, and abnormal physical features contributed to increasing the incidence of obesity. Therefore, the physicians recommend continuous monitoring to control this condition [99].

3.1.2 Other Problems that Related with Healthcare Field

In addition to healthcare problems, people with DS face other set of problems related to their health status. Among them, the most common are as follows:

A. Family-Doctor Approach

Smith shows that the family physician's approach is of great importance to provide good medical care for all people especially for individuals with DS [87], by providing medical guidelines that contribute to make decisions about health status [115]. In addition, their roles for planning the future life of people with DS by collecting all information of their daily life contributes in overcoming future challenges, including those related to health status [116]. Therefore, the lack of this factor leads to deficiencies in the evaluation of health status for individuals with DS [117].

B. Supporting

At present, the diagnosis of DS patients can be performed even before the child is born. For example, in United States, 87% of parents know their child is DS after they are born, a phenomenon leading to parental fear for the future of their child. In Spain, a survey of 467 mothers who have a child with DS concluded that they do not have an optimal health service

before the child's birth, and they recommend a professional physician to deal with them [118].

Marshall et al. have shown that individuals with DS and their parents need supporting in four cases: during child birth, access to medical services, managing medical services, supporting through their lives. They carried out the investigation a random sample consisting of 50 persons (5 therapists, 7 nurses, 25 coordinators, 10 English-speaking parents, and 3 Spanish-speaking parents) to understand the experiences of all the people who are dealing with DS patients. They identified many challenges, some of which related to lack special clinics for individuals with DS, and lack specialists to deal with them [119].

C. Health Insurance

Health insurance is the important health factor to support people by covering the cost of treatment that effected by health problems. Therefore, any lack of this factor leads inability of person to afford the high cost of treatment. due the higher cost of medical treatment of DS' patients (12 to 13 times higher than others [120]), the availability of this factor will be contribute to provide all healthcare services that they needs, which leads to enhance health status of them.

3.1.3 The Feasibility of Information Technology in Healthcare Field

As mentioned in the section 1.2, the main purpose of this thesis is to set a framework of designing a DSIS by investing on IT. Therefore, this section will be focused on the study the technical feasibilities that contribute to designing the aforementioned system. Many articles were surveyed to study the feasibility as and the gist of that information is presented below.

Time and place are critical issues that must be studied when designing any system, especially for systems to provide proactive services. Therefore, IT revolutions like IoT has contributed to ensure the availability of health services in the real time [21, 24].

Sensor networks contribute to developing health services by embedding them the health monitor systems [121] in order to capture vital signals of individuals and send them by special gateways to the central processing units [122]. Therefore, the reliance on these techniques has greatly increased in health monitoring systems to monitor the state of health [123]. As a case in point of this reliance, in United State and Colombia, the medical sensors are used medical systems for older people. They start to collect vital signals, and compare them with EHRs to detect potential health problems. With continued reliance on this system, specialists recommend to develop new medical-pattern-recognition-algorithms, which could contribute to increasing the efficiency of dealing with big medical data [124].

RFID is an electronic component that consists of a small chip and antennae. It is used for many purposes such as monitoring, tracking and authorization [125]. It has a role in developing and enhancing healthcare systems by using it as a medical sensor [126]. This technology is implanted closely to the surface of human skin to capture vital signals. Sometimes, RFID needs to be covered by special kind of medical casting to be suitable for human cells. The big challenge of using this technology is the movement under the skin, but this problem has been solved by using special materials to surround the tissue and growing over its face [127]. An example of RFID tags is VeriChip that it implanted inside human body. It consists of a coil of wires to transmit signals and a hermetically sealed microchip within a glass capsule for protection. This device is commonly used to differentiate patients according to the severity of their problem in order to reduce the time of hospital entering, especially in the emergency case like allergy [128].

Vehicular cloud computing (VCC) is a kind of cloud computing that serves the transportation system. This system uses VCC by enabling RFID to serve the healthcare sector. This system is used to authenticate people, and use this authentication to transfer the data within healthcare facilities. In addition, it contributes to reaching patients during movement [129].

The development of technology leads to integrated medical sensors with garment to capture high-efficiency vital signals [130]. Therefore, it has become common to obtain

medical signals, especially for critical cases like individuals with heart defects. For example, Marmaropoulos and his partners described a wearable garment that employs a medical sensor and has the potential for early detection of vital signals issued by the human body in a matter of the seconds, with the possibility of developing it to cover the entire human body [131].

Charlon and his partners have succeed to monitor the health status of old people by designing a smart insole and by using a microelectronic device to collect vital signals and transferred them for evaluation of the health status of old people [132].

Medical wearable-devices are presented as a bracelet gadget. These devices consist of quick response code and are connected to a smart phone. They are used for localization of the person by using Global Positioning System (GPS) enabled by the smart phone. A big problem faced in using this device is the area limitation, because the equipment to capture signals from these devices is not available in public places; they are limited to hospitals only. This device contributes to reducing the time and effort of patient entry process, as well as to determine their cases according to the patients' medical data [133].

In China, a mobile application called Mindo was develop by Lin and his partners. This system uses wearable and wireless technologies to measure and monitor the electrocardiogram (ECG) of drivers during their work and associated changes in their brain activity. This system helps the drivers to be safe by sending an alarm about the emergency cases [134].

The LifeShirt System developed by VivoMetrics relies on a smart garment with wearable sensors and integrated with personal digital assistant device to measures heart functions. This device was introduced in medical system and is based on wireless body area networks (BAN's) to make connections with patients with mobile applications. This system capture ECG signals and transfers them by short message service SMS to the clinic it is connected with [135].

The main requirements for depending on medical sensors in healthcare sector are capability to deliver services in real-time by preserving the privacy, reliability, and

security during the transfer of medical data [136]. These terms can encourage the society to invest in this technology in healthcare. However, using these devices has limitations such as not being suitable to be worn all the time which leads to discontinuous use [137]. In addition, they need further development on IoT to satisfy individual's needs. These limitations should serve as motivation to continue the development on communication fields to ensure better remote monitoring in real-time. Therefore, specialists propose to depend on the fixed devices side by side with wearable devices to ensure continuous monitoring [138].

Despite the great benefits of using medical sensors in monitoring system, they are facing challenges such as patients' movement which may distort his data, lead to communication cut, and introduce noise. Therefore, the specialists are continuing to developing algorithms for preprocessing and filtering the medical data [139].

In conclusion, wearable devices with medical sensors have contributed immensely in enhancing the provision of remote healthcare because it has proven to be reliable in capturing vital signals [140, 141] as well as providing a secure environment especially for people with disabilities. [142].

Wireless Sensor Network (WSN) is a kind of wireless network that includes spatial devices in the end edges (node) which are called sensors to capture physical and vital signals [143]. These signals contribute to monitoring the status about environmental and social conditions. Therefore, WSN works as a gateway to provide wireless connectivity for all nodes, stations, as well as users (end user and system workers') [144]. Therefore, it is important for usage in urban environment through integrating it in all fields of life [145].

The reliability of WSN is a motivation to integrate it with other social networks to create and develop medical-IoT, which is made up of three layers: sensor, gateway, and applications [145].

Wireless Body Area Networks (WBAN) is another kind of WSN which relies on medical sensors to transmit the vital signals of the body. It is also known as Body Area Networks (BAN) [146]. This health care monitoring system is integrated with hospital

to follow up the changes of physiological parameters of the patient, such as blood pressure and heartbeat of pregnant women. This system works within WBAN to collect irregular signals and send an SMS message to physicians through the medical center. This system helps hospitals to monitor the abnormal condition of patients [146, 147].

Humayun and his partners presented the impact of WSN in healthcare sector as follows [148]:

a) Using WSN to monitor the daily life of people, to detect elderly people's movements, monitor the taking of medications, provide telemedicine, and detect diseases like diabetes, asthma, and heart defects.
b) The challenges of applying this system are security, privacy, energy that ensures its continuous working, and synchronizing the data to ensure services in real-time.
c) The performance of WSN is based on its lifetime, response time and workers on this system.
d) The greatest advantage of WSN is in stopping the use of traditional monitoring based on wired devices. On the other hand, disadvantages are few, such as it could be uncomfortable for patients when it is implanted in their bodies, and patients can think the device might have access of their privacy.

Below, some examples of the usage of WSN in healthcare applications.

TeleHomecare system is a kind of RMMs that works based on WSN for elderly to protect them and provide the healthcare in real time. It works by using medical sensors to evaluate critical cases [149]. Hsieh and his partners studied the role of integrated wearable devices with special sensors and concluded that they could be effective in providing accuracy in detecting dangers around individuals with DS, in this way protecting them from these dangerous cases like falls or any other factors that leads to death [150]. Another telemedicine system was adopted as two-way communication interface between patients and physicians, also it has wearable sensors connected to

smart phones. This system proved its abilities to develop health care systems by providing services in real-time, detect critical cases, and decrease health care costs [151].

Moreover, the role of investment on IT in healthcare field still faces some challenges and security issues [152], such as:

a) Usability: some users face problems in using these devices for several reasons, like the complexity of the user interface.
b) The reliability of data: some sensors do not capture the correct signals due to their limited abilities.
c) The privacy: some people refuse to use these devices since they think they violate their privacy.

In addition, the interactive environment is constantly facing technical challenges that affect their sustainability. Therefore, Zhang and his partners published an article with the aim of eliminating some challenges related to technology which affect their reliability. These challenges are [153]:

a) Standardization of the network: Ultra-Wide Band (UWB) refers of the communication approach to reduce the energy of communications and provide a high bandwidth. A wireless internet service provider (WISP) is a technique used to provide Internet service that are based on wireless networking.

   Therefore, they recommend integrating sensors with UWB for big data, developing the WISP to save energy and integrate it with external sensors, and finally, integrate sensors with all WSNs to make them suitable for all networks and users.

b) Simplify sensors and their associated software to increase the reliability and use it in all fields, especially that of healthcare.
c) Reduce the production cost of the sensors which will lead to encouraging individuals to purchase and use it in all fields.

Therefore, many current studies are focused on these challenges. For example, most WSNs depend on battery to operate, and to ensure continuous working, new methods in energy optimization need to be explored. For these reasons, Biswas and his partners focused on these issues by proposing a distributed data-gathering algorithm to satisfy the connected targeting of the nodes based on demand. This algorithm proved high reliability for the lifetime of networks and nodes [154].

Data is the core structure of any system. Therefore, it always faces challenges in terms of security and volume.

Lacking security of data leads to loss of confidence between patient and therapist [155, 156]. In addition, the interference of data when using more than one sensor, leads to loss of reliability, which in turn affects the appropriate decision for medical cases [157]. Therefore, designers have always been interested in security issues and have provided solutions such as:

a) Using appropriate encryption to transfer data by using several algorithms with possibility of changing the algorithm encryption over the time [158, 159].
b) Use of vital body characteristics as cryptographic keys. For example, the heart pulses is a vital feature, and the measured signals are of an anarchic nature [160]. Therefore, the output of ECG can be used as random keys for cryptographics [161].

The volume of data also is a big challenge while developing any software system. As shown, the increase of reliance on medical sensors with garment leads to increased amount of data because signals are converted from analog to digital domains especially when it is needed to obtain medical data all over the time (like using a ECG recorder to monitor the status of heart). For this reason, Rieger and John published an article to describe this problem and they proposed to develop new algorithms to convert medical data by depending on adaptive sampling systems instead of constant sampling approach. They concluded that this model can help to decrease the amount of storage by about 38% [162]. Many other article have proposed alternative solution to this

problem. For example, a data compression processes effectively reduce the volume of data. Elgendi and his partners developed low-power alternative compression methodologies to enhance data transmission. They relied on electrocardiogram ECG signals as important vital signals to make diagnostic and screening. This algorithm enhanced the Compression Ratio (CR) and percentage root-mean-square difference (PRD) (CR = 6 and PRD = 1.88). Finally, this algorithm proved the efficiency of transmitting the ECG signals in real time [163].

Data security is a sensitive issue that has become a major challenge in designing any system. For any IT system, privacy, access control, connection, and data storage are real security challenges [164]. As presented, the integration between IoT and cloud computing has contributed to enhancing service provision and have become effective in filling some gaps like the storage and applications. This integration is facing security challenges as follows [165]:

a) Heterogeneity: The diversity of devices, operation systems and platforms leads immense problems when it comes to integrating IoT and cloud computing.
b) Performance: until now, the integration between IoT and cloud do not satisfy the required quality of providing services such as communications and storage.
c) Reliability: Until now, this integration is missing in reliability, especially for moving elements, like applications for motor control.
d) Big data: the big data is one of the bigger challenges due the huge volume and variety of data.

Therefore, many articles have been published to enhance the security issues by creating new approaches or improved algorithms. For example, Li and his partners proposed two schemes for encrypting data: First scheme works according to multi-key fully homomorphic encryption (MK-FHE) principle. The second scheme works according on a hybrid structure by combining the double decryption mechanism and fully homomorphic encryption (FHE) [166]. Second example is related to attempts to solve the privacy of data. Tonyali et al., tried to hide data by applying a FHE and secure

multi-party computation (secure MPC). This approach contributed to reducing the overheads as well as to preserve the privacy of aggregated data [167]. In another case, Taylor and his partners presented a TLSDeputy system, which is a middle-box-based system to protect residential networking. This system proved that it could provide a secure method of residential networking with minimal overheads [168].

In addition to the above challenges, it must mentioned that any system has a number of minimum requirements to work efficiently. Therefore, the healthcare-oriented systems are divided into vital status monitoring ones that depends on wearable or non-wearable devices, and remote healthcare surveillance ones that estimate individual's health-status and detects critical cases. An additional requirement is that of WSN, which ensures the efficiency of health-services provides them in real time, secure, private, and of satisfactory quality [169].

Recently, the attention on security of IoT has gained momentum which with that aim of minimizing and eliminating the vulnerabilities in developing monitoring systems, like data breaching hacking conversations, loss of data due to high transferring volumes, etc. Therefore, Fernandes et al., recommended applying the Open Web Application Security Project (OWASP) in all layers of SDLC. This approach was proposed as an enduring alternative to eliminate of the above challenges, as well as to reduce the cost of system maintenance [170].

3.1.4 Results of Observation

A. Health status of individuals with DS

According the observations on sections 3.1.1 and 3.1.2, the health status of individuals with DS faces the follows problems:

1. People with DS do not have the ability to describe their medical cases, because DS is a kind of intellectual disability, and people with this condition always need someone to supervise them.

2. People with DS face serious health problems, which range from normal to severe cases, each level needing a special of dealing with them.
3. People with DS and their families lack the necessary healthcare support like comprehensive health insurance and special hospitals for them.
4. The communication between doctors and people with DS is still weak because of absence of a proper approach by family doctors to solve their medical and social problems.
5. Individuals with DS need early medical intervention due to the abundance and diversity of health problems.
6. Sometimes, individuals with DS need immediate intervention, and due to lack of healthcare system form them, the medical facilities cannot provide health services in the real time.

B. Information technology and health status

As showed in Section 2.6, IT is still lagging in healthcare field for individuals with DS. Therefore, section 3.1.3 focused on the role of IT in healthcare field in general, and the results are as follows:

1. Monitoring system of health status has contributed to enhancement in providing healthcare services by detecting the critical cases.
2. Medical sensors have become commonplace in monitoring systems due to their reliability to capture vital signals of some health problems such as heart defects..
3. Although challenges of privacy and security in transferring medical data, recent studies have proven that these challenges can be controlled by improving the algorithms of encryption and data compression.

3.2. Construct Hypotheses

This is the second step of investigation, which aims to define hypotheses of this thesis that related on health status of DS patients.

As shown in section 3.1.4, the health status of individuals with DS and the role of IT is the motivation behind the plan to design a special system for DS patients. This system will ensure its implementation by setting up a framework to support the developers who will design it.

According of the observation in section 3.1, the demographic factors on the health status of individuals with DS are health problems and how support the individuals with DS. Therefore, these factors will be independent variables of health status.

In addition, the dependent variables were classified into 3 factors as follows:

A. Emergence and recurrence of health problems and dealing with individuals with DS lead to occur health problems.

   Therefore, they define as hypotheses H_{1J} and H_{2K} respectively, when J=1..4, and K=1..2.

B. Supporting of individuals with DS leads to a decrease in amount of supporting them.

   Therefore, it define as hypotheses H_{3L} when L=1..5.

Figure 3.2 shows the research model of the hypotheses of health status including the depending variables that will be define in sections 3.2.1, 3.2.2 and 3.2.3.

In addition, table 3.1, shows the definition of hypotheses of the health status of DS' patients.

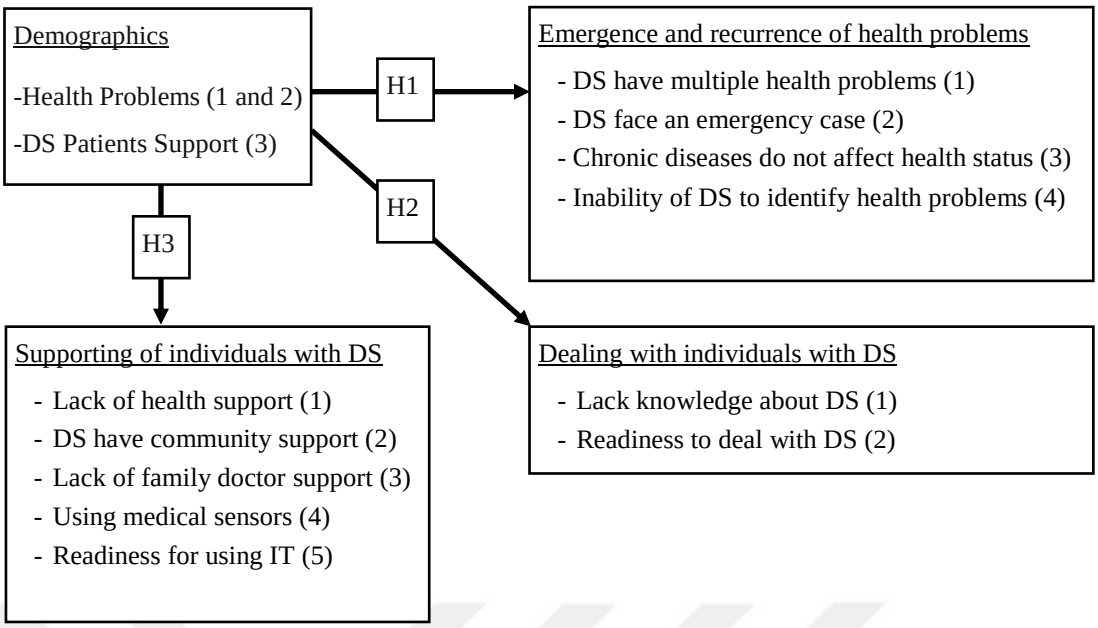

Figure 3.2 Research Model of Hypotheses of Health Status

Table 3.1 The Definition of Hypotheses of Health Status of DS Patients

Hyp.	Definition
H_{11}	DS have multiple health problems that range from simple to sever.
H_{12}	DS face an emergency case.
H_{13}	Chronic diseases do not affect health status such as diabetes.
H_{14}	Inability of DS to identify health problems due their health condition.
H_{21}	Lack knowledge of families about DS cases.
H_{22}	Readiness to deal with DS from the families and community.
H_{31}	Lack of health support such as health insurance.
H_{32}	DS have community support.
H_{33}	Lack of family doctor support to tracking their health status.
H_{34}	Using medical sensors to monitor their health status.
H_{35}	Readiness for using IT such as smart phones

3.2.1. Health Problems of Individuals with DS

As presented in section 3.1.1, individuals with DS have multiple health problems, which range from simple to severe such as a heart defects and diabetes. Some health problems lead to emergency cases that required immediate interventions on the affected individuals. However, previous studies have shown that individuals with DS have a number of chronic diseases like diabetes and Alzheimer. All these reasons lead to collapse the health status of individuals, especially for individuals with intellectual disability.

Therefore, the hypotheses that related with this dependent factor are follows:

H_{11}: Individuals with DS have multiple health problems.

H_{12}: Individuals with DS always face emergency cases.

H_{13}: Chronic diseases do not affect health status of individuals with DS due to lack of occurrence.

H_{14}: The inability of individuals with DS to identify health problems leads to collapse of their health status.

3.2.2. Dealing with Individuals with DS

As presented in section 3.1.1, families are not able to deal with individuals with DS due to lack of knowledge on this condition and health problems associated with it, which leads to further increase in health problems of the affected child. Simultaneously, they showed their readiness to help them.

Therefore, the hypotheses that related with this dependent factor are follows:

H_{21}: Lack of knowledge about DS.

H_{22}: Readiness to dealing with DS.

3.2.3. Supporting of Individuals with DS

As presented in sections 3.1.2 and 2.6, DS have support in some live sectors such as education, but they are still lagging behind in healthcare sector, which affects their health status. In addition, the lack of a proper family doctor approach affects on follow up their health status.

As presented in sections 3.1.3 and 2.6, although the role of investing IT in health field, it is still delayed for individuals with disability (including DS). This factor can affect the health status of individuals especially emergency cases, to provide immediate or proactive health services. However, this factor depends on the readiness of families to using IT approved by previous studies.

Therefore, the hypotheses that related with this dependent factor are follows:

H_{31}: Lack of health support.

H_{32}: DS have community support.

H_{33}: Lack of family doctor approach.

H_{34}: Using medical sensors.

H_{35}: Readiness for using IT.

3.3. Performing Experiments

This is the third step of investigation, which aims to test the hypotheses. Therefore, a questionnaire form was prepared to test hypotheses, and interviews with experts was conducted as follows.

3.3.1. Prepare and Implement a Questionnaire Form

The objectives of this step are:

1. Test hypotheses that defined in section 3.2 above.

2. Evaluate the health-status of people with DS.
3. Determine the most common health problem of people with DS.
4. Explore the role of IT in DS, especially in healthcare scope.

The procedures of this step are as follows:

A. Prepare the questionnaire form

A questionnaire form with fourteen questions was prepared to satisfy the above objectives as follow:

The initial questions of this questionnaire are related to collect some information about the participants. These are: 1) Gender 2) Age 3) Country.

These questions will contributed to use in future studies.

Section 2 of this questionnaire was contain the following questions.

Q1. Did you have any initial information on Down syndrome before your child was born?

This closed question contributes to evaluate and measure the background of families about DS. It will use to test H_{21}.

Q2. Does the person with Down syndrome have health problems?

This closed question contributes to check if individuals with DS have health problems or not. It will use to test H_{11}.

Q3. If the previous question is (Yes), determine the medical case.

This multiple-choice-question will contribute in evaluating health problems of people with DS. Therefore, according the previous studies in section 3.1.1, this question consists of 9 choices (Heart defect, Congenital anomalies, Gastrointestinal, Respiratory diseases,

Thyroid condition, Alzheimer, Diabetes, Vision diseases, and Infections). It will use to test H_{11}.

Q4. Does the person with Down syndrome have a family doctor?

This closed question contributes to evaluate the role of family doctors in the life of people with DS. It will use to test H_{33}.

Q5. Does the person with Down syndrome have any chronic disease?

This closed question contributes to assess chronic diseases of people with DS. It will use to test H_{13}.

Q6. How many times per year does the person with Down syndrome face emergency situation.

This multiple-choice question contributes to evaluate the volume of health problems for people with DS. It will use to test H_{12}.

Q7. Does the person with Down syndrome ever wear any medical device that incorporates medical sensors?

This closed question contributes to evaluate the role of IT in the life of people with DS. It will use to test H_{34}.

Q8. What is the capability of the person with Down syndrome to identify health problems?

This multiple-choice question contributes to assess the capability of people with DS to identify diseases. It will use to test H_{14}.

Q9. Does the person with Down syndrome have any health support?

This closed question contributes to assess the support in health scope. It will use to test H_{31}.

Q10. What is your evaluation of the health-care services provided for a person with Down syndrome are compared to other people?

This multiple-choice question contributes to evaluate the health-care services that were provided for people with DS. It will use to test H_{11}.

Q11. Does the person with Down syndrome have any community support in education or employment?

This closed question contributes to evaluate the support of community for people with DS. It will use to test H_{32}.

Q12. What is your evaluation of using PC's, smart phones, and any other communication devices in your environment?

This multiple-choice question contributes to evaluate the role of IT in the life of people with DS. It will use to test H_{35}.

Q13. What is your assessment of people's and society's view of individuals with Down syndrome?

This multiple-choice question contributes to evaluate the willingness of people to support people with DS. It will use to test H_{22}.

Q14. Do you have any suggestion or idea for them?

This question contributes to collect any ideas or notes that related with the life style of people with DS.

B. Coding the questionnaire form

After distributing the questionnaire and collect the feedback, digitalization was conducted to facilitate their analysis by SPSS software. Below, the digitization of the questionnaire form is shown.

There are 7 close questions (Q1, Q2, Q4, Q5, Q7, Q9, and Q11), with two answers (Yes/No). Table 3.2 shows the coding of close questions.

Table 3.2 Coding of Close Questions

Q Number	Value	Code
Q1, Q2, Q4, Q5, Q7, Q9, 11	Yes	1
	No	2

Question 3 is a checkbox, which contain 9 choices and one or more can be chosed. Therefore, this question was separated it in 9 sub-questions. Table 3.3 shows coding of checkbox question.

Table 3.3 Coding of Checkbox Question

Q Number		Value	Code	Notes
Q3	Q3-a	Yes	1	Heart defect
		No	2	
	Q3-b	Yes	1	Congenital anomalies
		No	2	
	Q3-c	Yes	1	Gastrointestinal
		No	2	
	Q3-d	Yes	1	Respiratory diseases
		No	2	
	Q3-e	Yes	1	Thyroid condition
		No	2	
	Q3-f	Yes	1	Alzheimer
		No	2	
	Q3-g	Yes	1	Diabetes
		No	2	

Q Number		Value	Code	Notes
	Q3-h	Yes	1	Vision disease
		No	2	
	Q3-i	Yes	1	Infections
		No	2	

Question 6 is a multiple choice-1, and it was coded as shown in table 3.4.

Table 3.4 Coding of Multiple Choice-1 Question

Q Number	Value	Code	Notes
Q6	Never	1	
	1 Time	2	
	2 Time	3	
	3 Time	4	
	4 or More	5	

Questions 8, 10, 12, and 13 are multiple choice-2, and they were coded as shown in table 3.5.

Table 3.5 Coding of Multiple Choice-2 Question

Q Number	Value	Code	Notes
Q8, Q10, Q12, Q13	Very low	1	
	Low	2	
	Moderate	3	
	High	4	
	Very high	5	

C. Training sample

Before distributing this questionnaire, the researcher applied it on a training sample (30 random samples) to measure its reliability. The SPSS software was used the reliability statistics function (Cronbach's Alpha), and the result was equal to 0.910 (Figure 3.3). This result is more than 0.7, meaning that the questionnaire is reliable to be applied on the real sample.

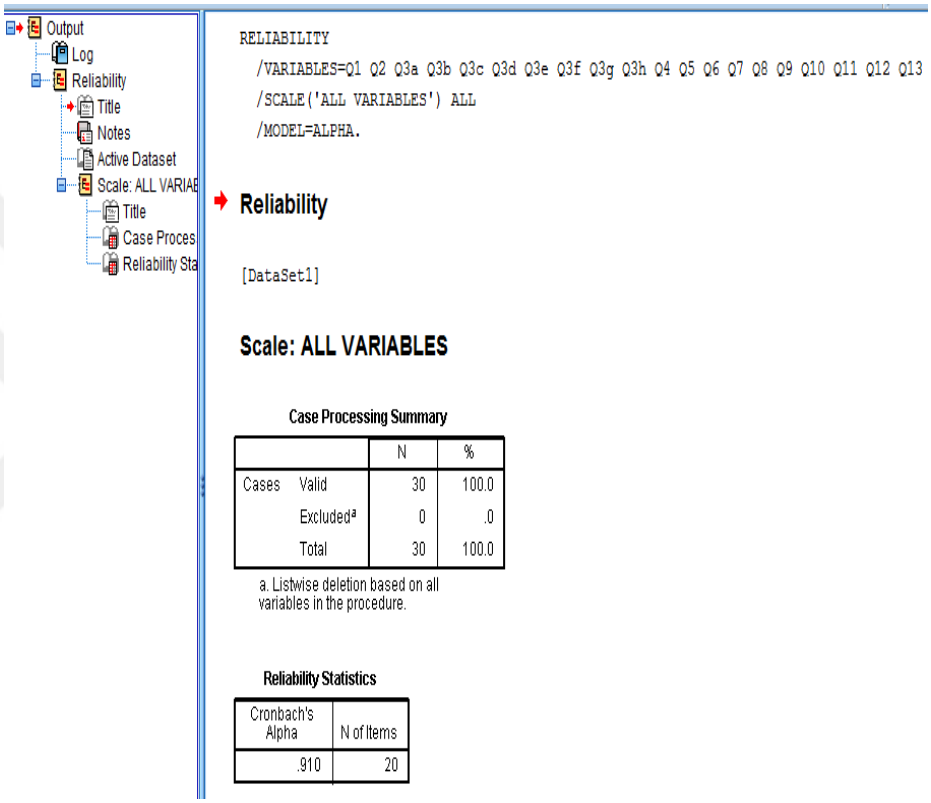

Figure 3.3 Reliability of Questionnaire Form

D. Appling the questionnaire on real sample

The reliable questionnaire was applied on the real sample by distributing it among families who have a member with DS. It was proposed to distribute it among some Arabic countries including Iraq, in order to study the life style of individuals with DS in different countries. Therefore, the cluster sample was used to distribute this form (due the difficulties and increased cost of collecting feedback), and it is closed on January 15, 2018. The results of are describe in figures 3.4 to 3.16.

Q1/ Did you have any initial information on Down Syndrome before your child was born?				
# of Participant		151	No answer	6
Answers	Yes	47	32.41%	
	No	98	67.59%	

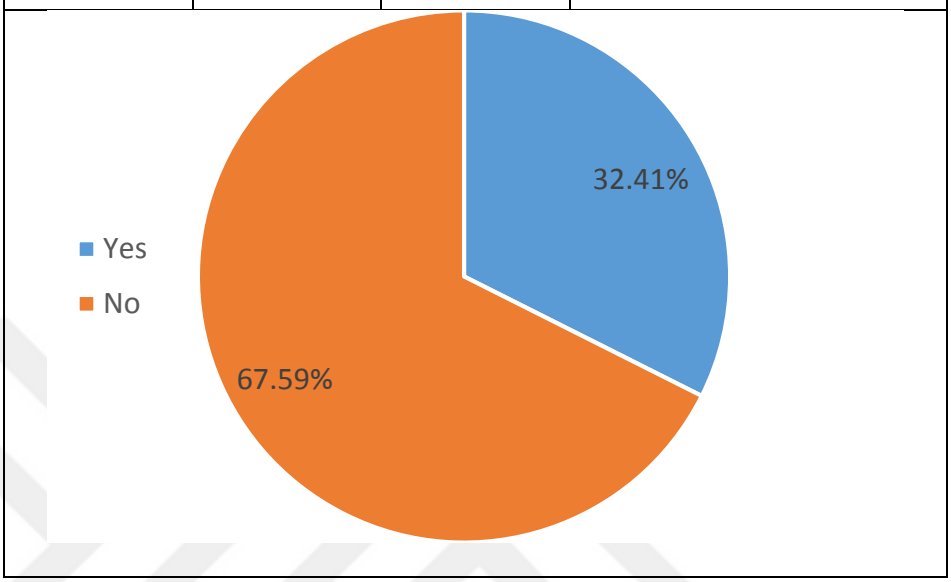

Figure 3.4 Results of Question 1 of Questionnaire Form

Q2/ Does the person with Down's syndrome have health problems?				
# of Participant		151	No answer	8
Answers	Yes	113	79.02%	
	No	30	20.98%	

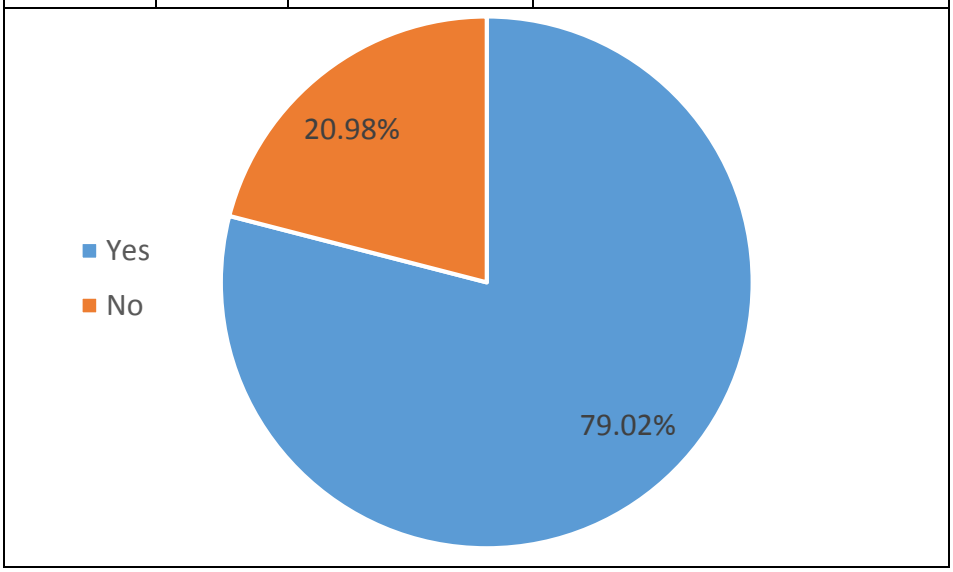

Figure 3.5 Results of Question 2 of Questionnaire Form

Q3/ If the previous question is (Yes), determine the medical case.			
# of Participant	151	No answer	37
Answers	Heart defect	69	60.53%
	Congenital anomalies	14	12.28%
	Gastrointestinal	22	19.30%
	Respiratory diseases	34	29.82%
	Thyroid condition	11	9.65%
	Alzheimer's	2	1.75%
	Diabetes	2	1.75%
	Vision diseases	17	14.91%
	Infections	17	14.91%

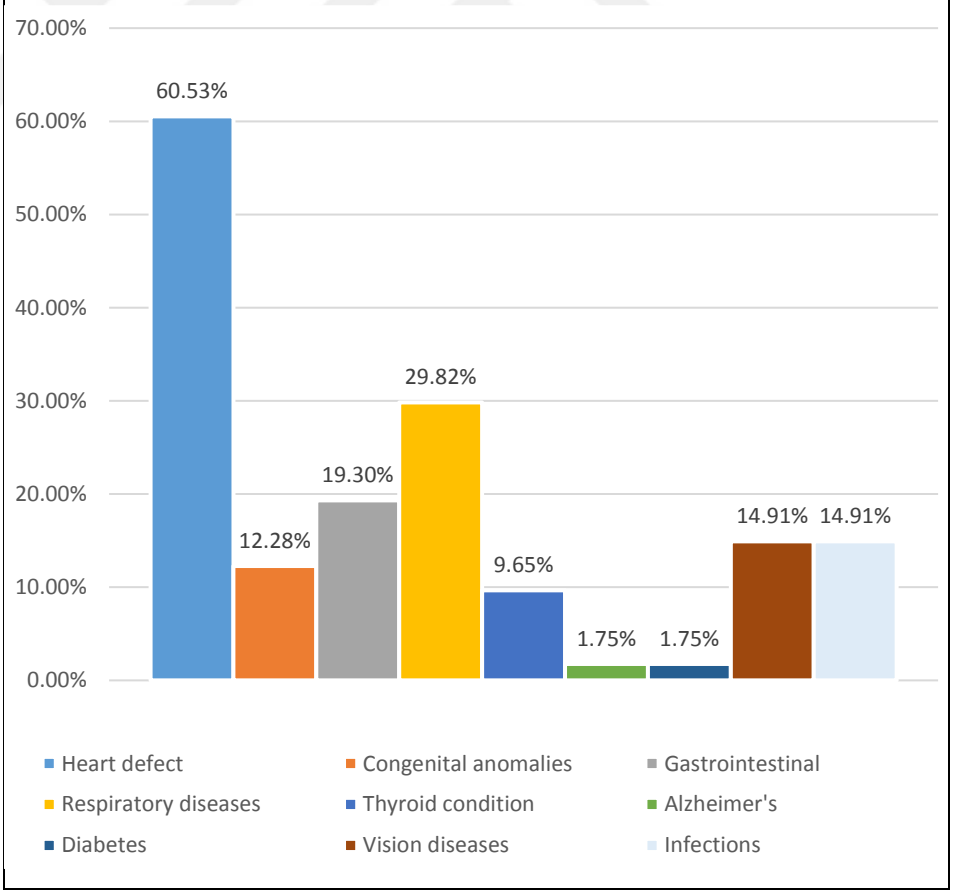

Figure 3.6 Results of Question 3 of Questionnaire Form

Q4/ Does a person with Down syndrome has a family doctor?				
# of Participant		151	No answer	6
Answers	Yes	43	29.66%	
	No	102	70.34%	

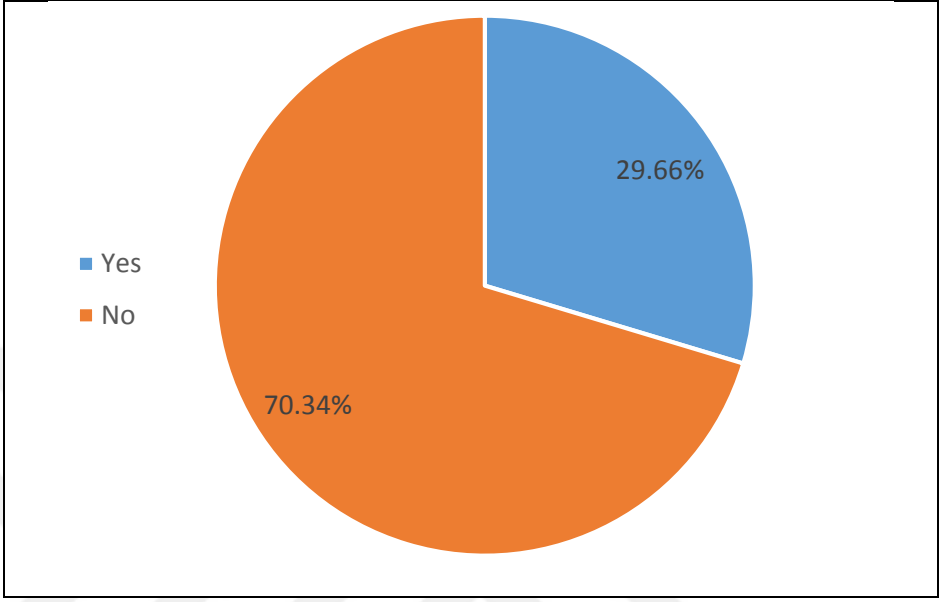

Figure 3.7 Results of Question 4 of Questionnaire Form

Q5/ Does a person with Down syndrome have any Chronic disease?				
# of Participant		151	No answer	7
Answers	Yes	45	31.25%	
	No	99	68.75%	

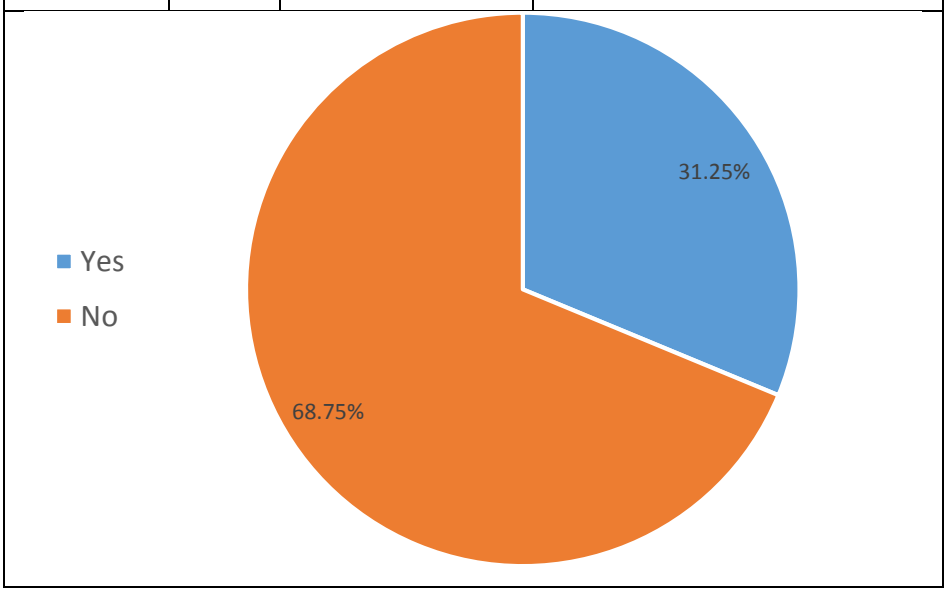

Figure 3.8 Results of Question 5 of Questionnaire Form

Q6/ How many times per year does the person with Down syndrome face an emergency situation?				
# of Participant		151	No answer	12
Answers	Never	22	15.83%	
	1 Time	23	16.55%	
	2 Times	25	17.99%	
	3 Times	18	12.95%	
	4 or more times	51	36.69%	

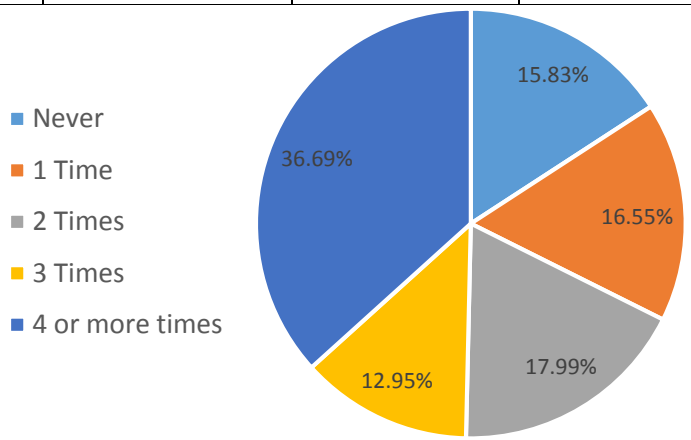

Figure 3.9 Results of Question 6 of Questionnaire Form

Q7/ Does a person with Down syndrome ever wear any medical device that incorporates medical sensors?				
# of Participant		151	No answer	15
Answers	Yes	23		16.91%
	No	113		83.09%

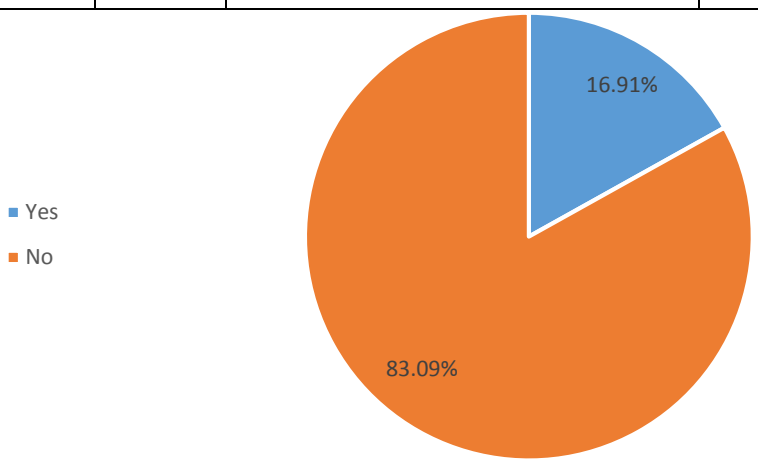

Figure 3.10 Results of Question 7 of Questionnaire Form

Q8/ What is the capability of the person with Down Syndrome to identify health problems				
# of Participant		151	No answer	20
Answers	Low	30	22.90%	
	Little	21	16.03%	
	Some	39	29.77%	
	A lot	19	14.50%	
	Too much	22	16.79%	

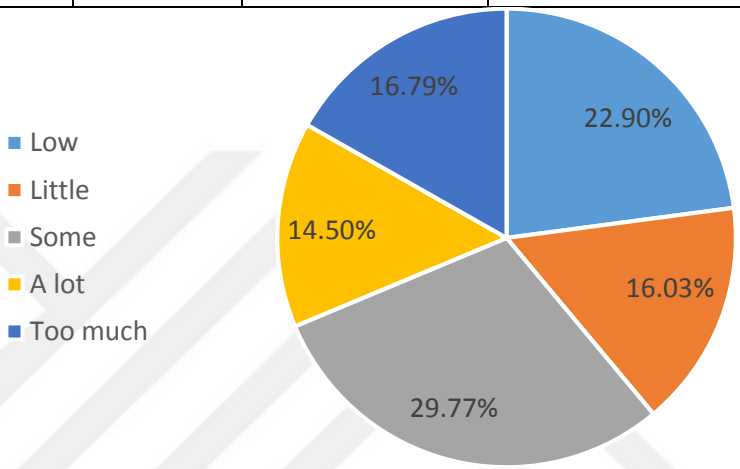

Figure 3.11 Results of Question 8 of Questionnaire Form

Q9/ Does the person with Down syndrome have any health support.				
# of Participant		151	No answer	8
Answers	Yes	27	18.88%	
	No	116	81.12%	

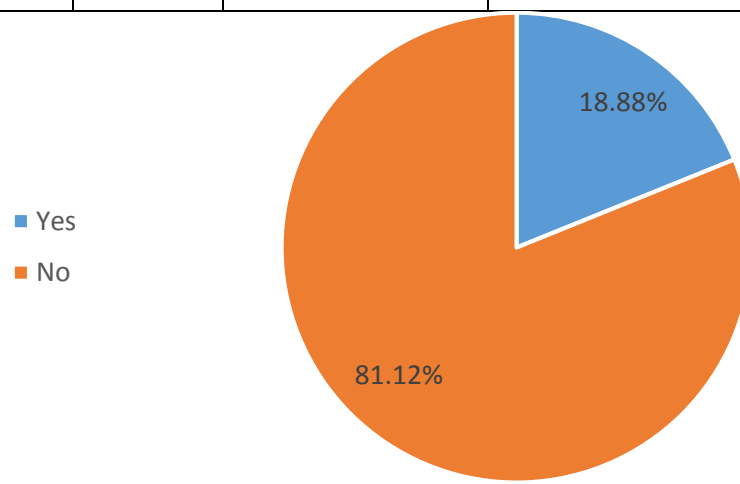

Figure 3.12 Results of Question 9 of Questionnaire Form

Q10/ What is your evaluation of health services provided for a person with Down syndrome are compared to other people?				
# of Participant		151	No answer	8
Answers	Low	72	50.35%	
	Little	26	18.18%	
	Some	28	19.58%	
	A lot	6	4.20%	
	Too much	11	7.69%	

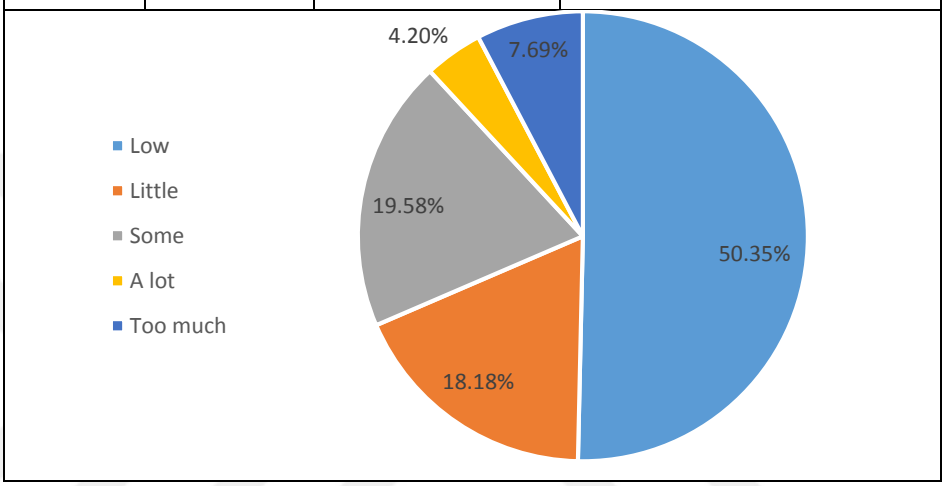

Figure 3.13 Results of Question 10 of Questionnaire Form

Q11/ Does the person with Down syndrome have any community support in education or employment.				
# of Participant		151	No answer	7
Answers	Yes	31	21.53%	
	No	113	78.47%	

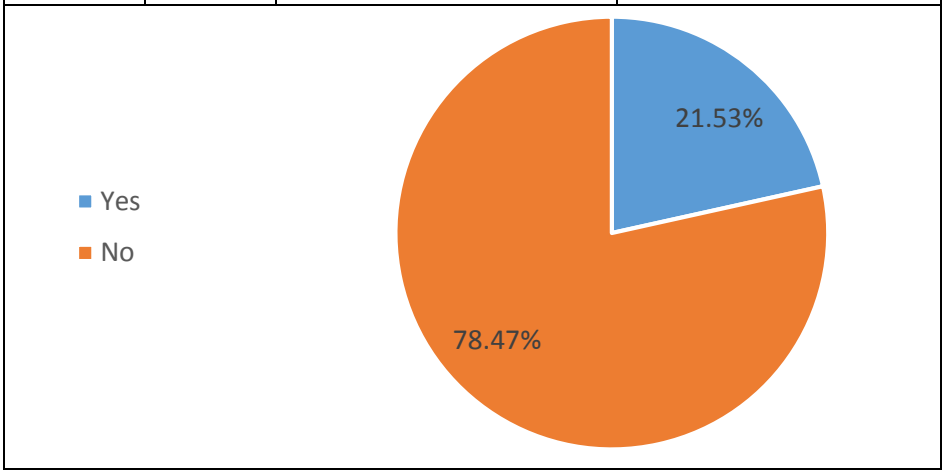

Figure 3.14 Results of Question 11 of Questionnaire Form

Q12/ What is your evaluation of using PC's, smart phones, and any other communication devices in your environment?				
# of Participant		151	No answer	11
Answers	Low	18	12.86%	
	Little	23	16.43%	
	Some	34	24.29%	
	A lot	32	22.86%	
	Too much	33	23.57%	

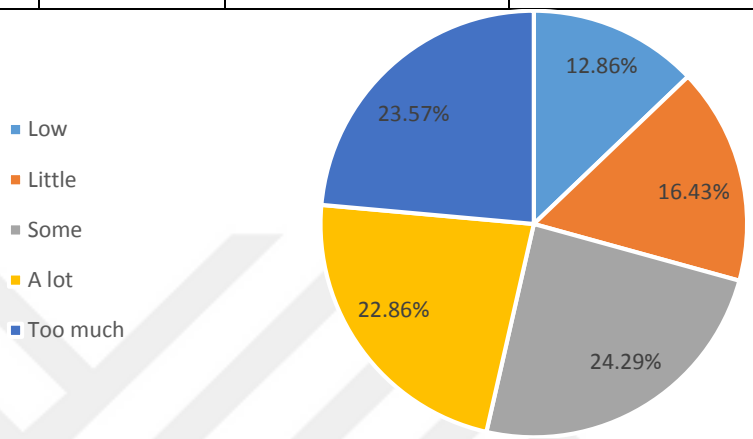

Figure 3.15 Results of Question 12 of Questionnaire Form

Q13/ What is your assessment of people's and society's view of individuals with Down syndrome?				
# of Participant		151	No answer	8
Answers	Low	35	24.48%	
	Little	18	12.59%	
	Some	42	29.37%	
	A lot	24	16.78%	
	Too much	24	16.78%	

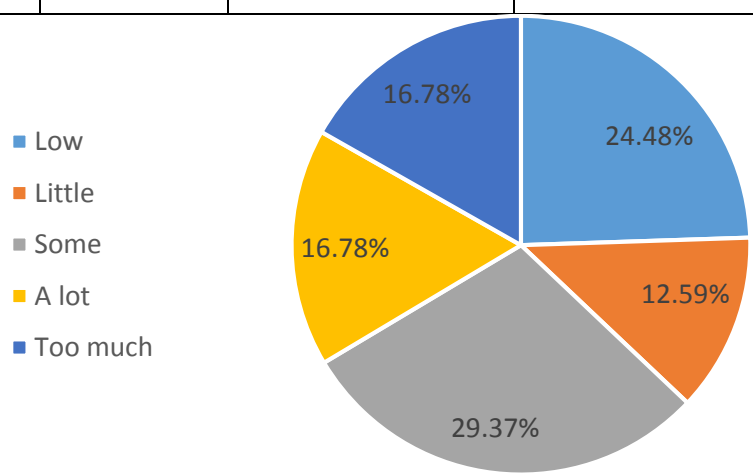

Figure 3.16 Results of Question 13 of Questionnaire Form

Question 14 is an optional question that aims to collect some recommendation from participants. Table 3.6 shows the 85 feedback was collected and summarized as groups.

Table 3.6 Summary of Question 14 of Questionnaire Form

Needs government support	31
Needs special institute for them	12
Increase people' awareness to deal with people with Down syndrome, by special courses	13
Increased attention to Down syndrome from birth	15
Special courses for the parents on how to deal with these cases	14

In addition, the results of the initial section of the questionnaire form as shown in table 3.7 below.

Table 3.7 Initial Information of Participants

Variable	Number	Percentage
Participant	151	
Gender		
Male	82	54.30%
Female	69	45.70%
Age		
<5	15	9.93%
6-18	69	45.70%
19-40	55	36.42%
>40	12	7.95%
Country		
Iraq	78	51.66%
Other Arabic country	73	48.34%

3.3.2. Interviews with Academic and Experimental Experts

In addition to the questionnaire form, interviews with experimental and academic experts were conducted to identify the methodology of designing the framework in Chapter 4.

A. Academic expert

The first academic expert from Turkey has 25 years' experience as a software developer. He provided a brief overview about the development process in general and specifically in Turkey.

According to hum, the main aspects of information systems are software, hardware, network, people and process. In the past, the developer used to deal with compilers to develop any system. Therefore, they do not have any problem in software and hardware because they are capable of handling every activity and solve any problem. With the progressing and revolution of ICT, began in the late 90's in Turkey and software optimization play a significant role in system development.

In Turkey, the developers started to use the waterfall model to develop systems. With appearance of the interactive languages like Java, this approach has become more efficient to develop systems. In addition, the principle of Service-Oriented-Architecture (SOA) contributes to increasing the evolution of developing software applications.

Management of human resources is one of the most challenging for organizations. It is interested in setting strategies for effective management of all processes and activities of people within the organization, which ensures to give competitive advantage to the organization [171]. Therefore, many articles have analyzed the role of these challenges. In Brazil, the end users have been available in the development process [172, 173], because it plays the main role in the success of any project by choosing experts and specialist staff. In addition, it creates positive

impacts on people by supporting and engaging them in specialized workshops. In addition to creating a spirit of competition among them. In Egypt, a previous experiment showed the abilities of 200 women in first aid activities. It started by distributing a questionnaire to collect initial data about their background of first aid. Following that, the participants conducted exercises according of instructions in a special workshop. This experiment concluded that the capacity of development approach has a role to enhance abilities of humans in the first aid activities, and special workshops contribute to increase participants' skills. [174]. Therefore, the expert recommended highlighting this issue to ensure an efficient design of any system. For example, the chair of development team should have sufficient accuracy to determine all activities, processes, and developers' team. The programmer shall have a lot of experience in coding all processes. The development team must consist of a sample of end users and some employees, who have an active role in determining and explaining all activities of the old system, and to define problems of old system.

Documentation is the second point confirmed by the expert. For example, if the organization distributes information about the product among 100 countries, documentation can be helpful for this organization to keep track and make the information accessible. Additionally, documentation contributes to transferring the latest development to all countries.

In another interview, a Turkish academic expert on developing engineering systems asserted that following the scientific method in development will ensure effective design of any system. For example, investigation is the first step of development, which contributes to identify system requirements. After that, imaging the proposed system by modeling it as flowcharts or as block to satisfy the requirements is necessary. This flowchart is called the "logical design" of the system and shows the role of the people and the main components within the system. The logical design also shows functionalities of the system that are determined by experts

clearly. These functionalities refer to all communications and activities of system components that are represented by blocks. Until this step, the conceptual design will be ready for sending to the developer to code it. This conceptual design must be modelled according to real life scenarios, which ensure to determine the requirements and activities of the system as well as its correct implement. Coding by the developer will start to implement the system. The last step is testing: this step shall be applied on a real sample to ensure user satisfactions. It is necessary to implement a first version (V_0) of the proposed system (beta version) and collect feedback to update it accordingly and upgrade it to higher versions. In conclusion, applying the scientific method to develop any system ensure to the design of optimal systems that satisfy users' needs, and the following issues must be taken into consideration:

1. Make the design flexible for use by all participants.
2. Support the proposed system through constant updating.
3. Documentation of all steps will contribute to better exploration of the problems.
4. Feedbacks contribute to ensure continuous work of the system.
5. The function must be simple and satisfying the end users' needs.
6. Be careful about the priority of functions and activities in the system.

All these notes can be useful to set an optimal framework to start designing any system.

An online interview with an academic expert from Iraq was conducted to learn more about challenges of developing a special school.

1. Study the feasibility of old system to identify the problems and the feasibility of technologies that contribute to developing the new system.

2. Participating end users in development contribute to determine user requirements efficiently.
3. The prototype should be designed and tested on a real sample to fix potential and real errors of the system.

B. Experimental expert

In addition to the interviews with academic experts, interviews with experimental experts were conducted to gather practical experiences in system development.

Supporting individuals with DS in all field areas contributes to estimate and develop their abilities. Education field is one of the important in human life. Therefore, an interview via mobile application (WhatsApp) was conducted with the directing manager of one of a special school in Northern Iraq to get more information about the skills that need to be developed in education sector for students with disability. The school uses an interactive and partnership-based model among staff, students, parents and community to develop a smart education system. It starts by carefully studying the disability case and applies the necessary modern technologies to support them. After that, they determined their objectives as followed:

1. Develop an interactive learning environment between the school and students.
2. Support parents through interactive communication between the school and parents.
3. Early detection of special cases for students.
4. Making education accessible for all students.

After analyzing these objectives, they start to build an interactive environment by setting a web site of this school.

The big challenges that face this project are:

1. How to determine the disability cases?
2. What is the optimal method to provide services?
3. How can they help and support disabled children's parents?

Therefore, they developed the followings to eliminate these challenges:

1. Obtain a patent to use and apply online Portage application tools for all students. This application contributes to measure the mental abilities of students.
2. This school is also working to apply a tracking system to follow up all students between home and school. This system is working based on some mobile application and GPS. This tool has contributed to decrease the problems that occur during travelling and increased parents' confidence on the school.

Finally, it was noticed that the development plan based on this framework contributed to successfully applying this project, i.e., good planning and the right framework ensured the success of the project.

Another interview was held with the assistant general manager of one of the biggest company, which are develop GIS software in Turkey. This company is working to develop a special navigation system for blind people to monitor them in their daily life. After introduced the traditional introduction about the development system, the following questions were submitted:

1. How can you start to collect and determine the requirements of any system?
2. Can you talk about the problems that you faced or expected to face when you were developing system?
3. What are your priorities in developing any system?
4. After setting up the first version, what do you do to guarantee that the software works forever?

The expert submitted his experiences on system development life cycle approach and concentrated on investigation, analysis, design, Implementation and maintenance.

1. About the investigation and analysis to determine the requirement of the system. In general, it differs according of the end user, which means that, if it is for blind people, it should collect the essential requirements as negotiated between developers and blind people. If the end user is a government (as a tender), definitely it is recommend some requirements according the properties of the tender. For example, for the proposed system for blind people, a special team should make an investigation by contacting with the real sample (blind people), to identify the requirements, and the objectives of proposed project.

   In addition, analyzing the requirements contributes to build a logical design by determined all activities of it.

2. For designing a system, the important thing that needs to be taken into consideration is the user-status, especially when dealing with disabilities. For example, to develop a navigation system for blind people, it must consider carefully about the fact that the blind people do not have an ability to imaging the structure of the road. Therefore, if the system guides him to turn left and there are two road in that direction, the old system cannot guide blind people to choose the correct road.

   Therefore, the expert should work to develop a new system to solve this problem based on user-status.

3. In implementation, most developers use simulation to implement and test the system. This approach is useful but it should be considered carefully, because sometimes simulations cannot pinpoint all the problems since some parameters such as speed and

time can differ. Therefore, it is better to make the implementation on a real sample to make the update in real time.

4. Last step is maintenance, which involves updating, supporting and redesigning the system to satisfy the requirement of end user and so on. However, the most important thing is the continuity of the system to work with any modern technology. New versions of technologies or software (operating systems for mobile like window in the past and Android in the present) are expected to appear in the future. Therefore, if something like these happen, the system must be flexible to adopt quickly to guarantee the continuous work.

Another experimental expert from Turkey worked on education by using a smart storytelling toy. She gave some notes about the development according on their experience. Indeed, she was in full agreement with the rest of the experts regarding the identification of requirements, its roles in planning the structure of design, and she emphasized the role of parents' participation, especially when dealing with disabled children. About the design step, she put a lot of importance in setting a prototype of the system and apply it on a real sample to define the problems and fix them quickly. About the implementation step, she pointed out that it was important determine the limitation of implementation, especially in the first version of the system. Such that, if the new system aims to develop the education aspect of people with disability, in the beginning it must be applied to one kind of disability only (like blind people), and then extend it to involve other people in the next version.

An expert for developing systems from Iraq focused on documentation as one of the keys to success of any system. Therefore, he recommended the followings:

1. Identify the system information that is used as a reference for development team such as: the main needs or requirements of the

system, functions that satisfy the user requirements, variables of the system that change within it, and structure of the system that make it working flexibly.

2. Determine the volume of documentation on coding. This step can be useful when the system codes are huge and allows explaining all codes and their benefits. In addition, this step can be useful when updating this system.
3. Identify the documentation tools that depend on the programming language. For example, as Word-processing programs like Microsoft Word tools can be suitable for any program languages.
4. Documentation must be in all development step like on planning, identifing the requirement, designing, implementation and maintenance.
5. Make documentation about system defects or failures when applying the initial version of the system. This process contributes to recovering the system and not repeat the mistakes in the future.

3.4. Analyze and Results of the Experimentation

3.4.1 Analyze the Questionnaire Form

In this step, the SPSS software was used to analyze the results that contributed to the acceptance or rejection the hypotheses in section 3.2.

A. Prepare feedbacks' data

The first step of analysis is to prepare the feedback's data. Therefore, generating the necessary parameters for analysis is necessary, and they are as following:

1. HealthProblem is a dependent parameter generated according to feedbacks related of the health status of individuals with DS, which is used to accept or reject H_{1J} and H_{2K}, when J=1..4 and K=1..2. In summary, it means following:

a) Determine the most common health-problems faced by individuals with DS. It takes "1" if they have at least one health-problem, otherwise it takes "0".
b) Compare it with other parameters that effect of health status.

2. Supporting individuals with DS means, providing assistance for them through basic services that support their health, such as health-institutions, enhancing community awareness and encouraging the use of IT in healthcare.

   These generated a dependent parameter called (SupportProblem) according to feedback from questions related support, and it is used to accept or reject H_{3L}, when L=1..5. This is means it used for the following:

   a) Used to determine the status of support for individuals with DS. Therefore, it takes "1" if the individuals have support for at least one problem. Otherwise, it takes "0".
   b) Compare it with HealthProblem parameter to estimate the relation between health problem and support for individuals with DS.

3. Generat parameters for multiple-choice questions to estimate or evaluate issues that are related to these questions (Figure 3.17), as follows:
   a) P_Q6 parameter: this parameter is used to evaluate the number of emergency cases that are faced by individuals with DS. Therefore, it takes "1" if they face more than one emergency case. Otherwise, it takes "0". This parameter is used with HealthProblem parameters to test H_{12}.
   b) P_Q8 parameter: this parameter refers to the capability of individuals with DS to deal with their problems. Therefore, it takes "0" if the score is more than two (DS do not have problem to deal with their health-problems). Otherwise, it takes "1".

This parameter is used with HealthProblem parameters to test H_{14}.

c) P_Q10 parameter: this parameter is used to estimate the healthcare services provided to individuals with DS. Therefore, it takes "0" if they have two or higher score (they have good or better service). Otherwise, it takes "1". This parameter is used with SupportProblem parameters to test H_{11}.

d) P_Q12 parameter: this parameter is used to evaluate the usage of IT from humans. Therefore, it takes "0" if the human use it at least a little (no problem to invest IT). Otherwise, it takes "1". This parameter is used with SupportProblem parameters to test H_{35}.

HealthProblem	Q4	Q5	Q6	P_Q6	Q7	Q8	P_Q8	Q9	Q10	P_Q10	Q11	Q12	P_Q12	Q13	SupportProblem	var
1	0	0	2	1	0	2	1	0	1	1	0	2	0	1	1	
1	0	0	0	0	1	2	1	1	3	0	0	4	0	5	1	
1	0	1	4	1	0	3	0	0	3	0	0	5	0	5	0	
1	1	1	0	0	0	1	1	1	3	0	1	3	0	5	1	
1	0	1	2	1	1	3	0	1	3	0	1	3	0	3	1	
1	1	0	4	1	0	1	1	0	1	1	0	3	0	1	1	
0	1	0	0	0	1	2	1	0	1	1	0	3	0	3	1	
1	0	0	2	1	0	3	0	0	4	0	1	4	0	5	0	
1	1	1	0	1	1	1	1	0	1	1	0	2	0	3	1	
1	0	0	3	1	0	2	1	0	1	1	0	4	0	3	1	
1	1	0	0	1	1	3	0	1	4	0	0	4	0	4	1	
1	0	0	2	1	0	1	1	0	1	1	0	1	1	2	1	
1	0	1	3	1	1	1	1	1	1	1	0	3	0	2	1	
1	1	0	4	1	0	3	0	1	1	1	0	5	0	2	1	
0	0	0	2	0	1	3	0	0	1	1	0	2	0	1	1	
1	0	0	2	1	0	1	1	0	1	1	0	1	1	3	1	
1	0	1	0	0	0	1	1	0	1	1	1	1	1	1	1	
1	1	1	4	1	1	1	1	0	1	1	0	2	0	2	1	
1	0	1	2	0	0	1	1	0	1	1	0	5	0	4	1	

Figure 3.17 Parameters of Multiple-Choice Questions

B. SPSS analysis of the results

After preparation of parameters presented above from the results obtained by the questionnaire form the real sample, SPSS software was used to

analyze the data and Pearson correlation function was used to assess the correlation questions of the questionnaire form.

Figures 3.18 and 3.19 below shows the steps of applying this function.

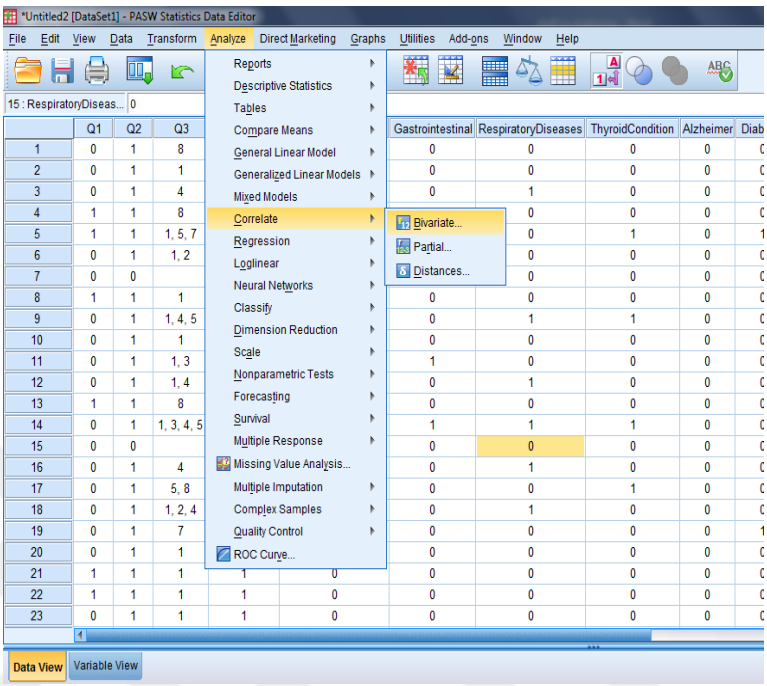

Figure 3.18 Apply Correlation Function

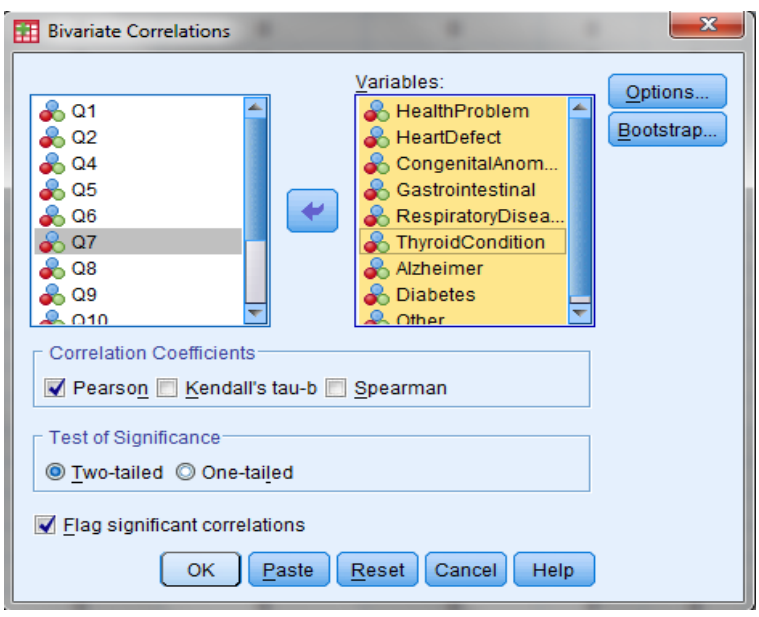

Figure 3.19 Execute Correlation Function

Table 3.8 below shows the results of Pearson correlation function between HealthProblem parameter and question 3, and shows, that most of the health problems are affected by the health status of individuals with DS.

Table 3.8 Correlation between HealthProblem and Q3

Correlations

		Heart Defect	Congenital Anomalies	Gastrointestinal	Respiratory Diseases	Thyroid Condition	Alzheimer	Diabetes	Vision disease	Infections
HealthProblem	Pearson Correlation	.509**	.152	.193*	.244**	.132	.048	.048	.161*	.161*
	Sig. (2-tailed)	.000	.063	.018	.003	.106	.560	.560	.048	.048
	N	151	151	151	151	151	151	151	151	151

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3.9 below, shows the results of Pearson correlation function between HealthProblem parameter and questions 4-9 to show parameters that effect for the health status.

Table 3.9 Correlation between HealthProblem and Questions 4-9

Correlations

		Q4	Q5	P_Q6	Q7	P_Q8	Q9
HealthProblem	Pearson Correlation	-.484-**	.151	.556**	-.596-**	.421**	-.243-**
	Sig. (2-tailed)	.000	.064	.000	.000	.000	.003
	N	151	151	151	151	151	151

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3.10 below, shows the results of Pearson correlation function between SupportProblem parameter, HealthProblem parameter, questions 4, 7, and 9-13. These results show the parameters that have effect on supporting and healthcare issues.

Table 3.10 Correlation between SupportProblem and Questions 4, 7, 9-13

Correlations

		HealthProblem	Q4	Q7	Q9	P_Q10	Q11	P_Q12	P_Q13
SupportProblem	Pearson Correlation	-.309-**	.264**	.332**	.246**	.521**	-.021-	-.027-	.269**
	Sig. (2-tailed)	.000	.001	.000	.002	.000	.801	.743	.001
	N	151	151	151	151	151	151	151	151

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

3.4.2 Results of Interviews

According the interviews conducted with academic and experimental experts (section 3.3.2), the following results show the most command notes, as well as the recommendation that will use in Chapter 4, to design the proposed framework

1. Setting a framework by documenting all requirements, activities, and processes of the system, will contribute to ensure the correct implementation of the proposed system.
2. In investigation step, focus must be on the real user to determine the requirements.
3. Conceptual design for any system needs to be defined for the system requirements and activities in detail.
4. UML diagrams contribute to visualize how system works.
5. The user-status is required when considering setting the design.
6. User support is extremely important to ensure continuous system.

3.5. Discussion and Conclusion of Investigation

Fifth step is discussion and conclusion of the investigation. It consists of the followings:

3.5.1. Discussion of Investigation

A. Health problems

As showed in figure 3.2, health problems of individuals with DS is consider an independent factor of the health status of them. This factor was affected by emergence/recurrence health problems and lack of knowledge to deal with this condition as dependent variable.

About health problems, the description results in figure 3.5 shows that 79.02% of individuals with DS have health problems, which are compatible with the results of previous articles [80, 87]. These problems are range from normal to severe, which affect on the health status for individuals with DS. Figure 3.6 showed the most common health problems for individuals with DS. It shows that the Heart defect occurs at a high percentage for individuals with DS people (60.53% of individuals with DS), also table 3.8 approve that it has a positive correlation with the parameter of health problem (=0.509 with significant < 0.01 (=0.000)).

Means health problems will increase when the person has a heart defect and it compatible with the previous studies [80, 100, 101].

Respiratory disease is the second highest health problem with 29.82% of DS patients (figure 3.6), and table 3.8 showed it have a positive correlation with the parameter of health problem (=0.244 with significant < 0.01 (=0.003)). Means it compatible with the previous studies [80, 95-98], and it will be affect on the health status of individuals with DS.

Gastrointestinal diseases also one of the most common health problems that occurred in 19.30% of individuals with DS (figure 3.6). In addition, table 3.8 showed it has a medium positive correlation with the parameter of health problem (=0.193 with significant < 0.05 (=0.018)). Means it compatible with the previous studies [80, 99, 104-106], and it will be affect on the health status of individuals with DS.

Finally, Vision disease and Infections occurred in 14.91% of individuals with DS (figure 3.6), and according on table 3.8 they have a medium positive correlation with the parameter of health problem (=0.161 with significant < 0.05 (=0.048)). Means they are compatible with the previous studies [80, 93, 94, 114], and they will be affect on the health status of individuals with DS.

These health problems prove what has been obtained in figure 3.13 that healthcare services is not provide well for individuals with DS, which leads to collapse of the state of health for them. In addition, table 3.10 shows a positive correlation with the parameter of supporting (=0.521 with significant < 0.01 (=0.000)).

These results were contributed to accept H_{11}, which talking about the individuals with DS have a multiple health problems.

For Congenital Anomalies and Thyroid diseases, the description results in figure 3.6 (12.28% and 9.65% respectively), and correlation results in

table 3.8 showed a limited correlation between these diseases and the parameter of health problem (=0.152 with significant > 0.05 (=0.063) and =0.132 with significant > 0.05 (=0.106)) respectively). Means these diseases have a limited affect for the health status of individuals with DS.

Repeated exposure of the emergency case indicates that the person has serious conditions that required an immediate intervention and ongoing follow-up. This is what has been obtained from the description results of figure 3.9, as 84.17% of individuals facing an emergency case (36.69% more than 4 times, 12.95% more than 3 times, 17.99% more than 2 times, and 16.55% one time). In addition, table 3.9 shows that the repeated of emergency case has a positive correlation with the parameter of health problem (=0.556 with significant < 0.01 (=0.000)), which leads to accept H_{12} that shows this condition leads to collapse the health status of individuals with DS.

The previous studies in section 3.1.1.1/I, shows that the chronic diseases is not common for individuals with DS, but specialist doctors recommends to monitor it for old people. This is what has been obtained in figure 3.8 (68.75% of individuals with DS have chronic diseases). Table 3.9 shows a limited correlation between chronic diseases and the parameter of health problem (=0.151 but the significant >0.05 (= 0.064)). In addition, table 3.8 shows a limited correlation between the parameter of health problem and Alzheimer and diabetes (=0.048 but the significant >0.05 (= 0.560)). These results leads to accept $H_{13,}$ which means the chronic diseases does not affect of parameter of health problem.

As known, the person can know that he face a health problem through the some symptoms, but individuals with DS cannot know it, due their health condition (DS is a kind of intellectual disability [1]). Therefore, individual with DS unable to identify and know their health problem (figure 3.11). In addition, table 3.9 showed a medium correlation between this issue and the parameter of health problem (=0.421 with significant < 0.01 (=0.000)),

which means the individual with DS unable to identify health problems and leads to accept H_{14}.

The dealing with individual with DS is depends on the families knowledge and their readiness to work with them. For families' knowledge, figure 3.4 showed 67.59% of families do not have any idea about DS, which leads to their inability to deal with them. This percentage was compatible with previous study in section 3.1.2/B, and prove this deficiency will affect on the health status of individuals with DS. Means accept $H_{21,}$ which talking about families have an enough knowledge for dealing with individuals with DS, which leads to appear health problems.

Otherwise, figure 3.16 shows 62.93% of families are ready to help and work with individuals with DS (29.37% some of them are readiness, 16.78 a lot of them are readiness, and 16.78% many of them are readiness). In addition, table 3.10 proved that is a medium correlation between the readiness of dealing with DS and the parameter of support problem (=0.269 with significant < 0.01 (=0.001)), which leads to accept H_{22} of this thesis.

B. DS patient support

As showed in section 3.2, supporting of individuals with DS can leads to enhance their health status, means it consider an independent factor of the health status of them. Table 3.10 showed a negative correlation between the parameter of support problem and the parameter of health problem (=-0.309 with significant <0.01 (=0.000)), which proved that the decrease of supporting leads to increase health problems.

This factor used to test H_{3I} (when I=1..5), and it depends on many sub-factors. Health support like insurance was contributed to enhance health status as showed in previous studies in section 3.1.2/C. Therefore, the description results in figure 3.12 prove that the 81.12% of individuals with DS do not have a health insurance. Table 3.10 approved that it has a

positive correlation with the parameter of support problem (=0.246 with significant < 0.01 (=0.002)), which means the supporting was increase when increase the health insurance. In addition, table 3.9 showed that the insurance of supporting has negative correlation with the health status (=-0.243- with significant < 0.001(=0.003)), which means it affect of the health status. These results leads to accept H_{31}.

Despite some attempts to support the individuals with DS in education and employment field [22, 25, 38], it still limited. Figure 3.14 showed these people do not have this kind of supporting (78.47% of them miss a support in education or employment field), but table 3.10 showed limited correlation between this kind of support and the parameter of support problem (=-0.021- with significant > 0.05 (=0.801)), which leads to reject H_{32} because this thesis is focus on healthcare field. However, this result can be benefit to use in future studies to enhance supporting these people in education and employment fields.

As presented, family doctor approach is contributes to comprehensive medical services in all people including with DS (section 3.1.2/A). Moreover, figure 3.7 showed 70.34% of them do not have a family doctor. In addition, table 3.10 showed a medium correlation between the family doctor approach and the parameter of support problem (=0.264 with significant <0.01(=0.001)). Table 3.9 showed a negative correlation between the family doctor approach and the parameter of health problem (=-0.484- with significant < 0.01 (=0.000)). These results approved that the lake of family doctor approach affect to decrease the supporting that affect on the health status of individuals with DS, which leads to accept H_{33} of this thesis.

As presented, medical sensor was used to enhance providing healthcare services (sections 2.6 and 3.1.3). However, figure 3.10 showed 83.09% of them do not used this device. In addition, table 3.10 showed a medium correlation between using medical sensor and the parameter of support

problem (=0.332 with significant <0.01(=0.000)). Table 3.9 showed a negative correlation between using medical sensor and the parameter of health problem (=-0.596- with significant < 0.01 (=0.000)). These results approved that the lake of using medical sensor affect to decrease the supporting that affect on the health status of individuals with DS, which leads to accept H_{34} of this thesis.

However, figure 3.10 showed 70.72 of individuals are readiness to use IT applications (as 24.29% some people use IT, 22.86 % a lot of people use IT, and 23.57% many people use IT). In addition, table 3.10 showed there is no correlation between using IT applications and the parameter of support problem (=-0.027 with significant >0.05(=0.743)), which proved the IT still not invest to support people in healthcare field. These results leads to accept H_{35} that focus on readiness of using IT although to not invest it in healthcare field.

3.5.2. Conclusion of Investigation

The discussion section proved that the factors of health problems and support DS patients were became independent variables and affect on the health status of individuals with DS (section 3.5.1). Some health problem such as heart defects can be monitors by using medical sensors (as proven in section 3.1.4/B). In conclusion, the proposed system (DSIS) will contribute to enhance health status of DS' patients by using medical sensors, means this system is compatible with the researcher motivation. In order to choose an planning to ensure implement DSIS, section 3.4.2 proven that the framework is a technical tool to ensure implement this system, by describe and visualize all components of it to become an educational guide for developers. Therefore, this thesis will appear to set this framework by the conceptual design of DSIS to describe components of it and visualize it through UML diagrams as shown in Chapter 4 later.

In addition, the proposed system will works by managing the medical review for health problem, which compatible with previous studies (section 3.1.1). These studies were recommended to make and repeat medical tests for all diseases to evaluate health status. Therefore, this thesis was conducted a classification of providing healthcare services according to the type of diseases and the medical tested that were recommended by physicians (table 3.11). This classification was shown the most common health problems of DS patients and the tests that needs, and classified the medical tests as:

- Early test for critical health problems like heart defects.
- Routine tests for health problems in general.
- Immediate tests for emergency cases of some of health problems such as heart defects and infections.
- Annual tests for most of health problems to assess the health status.

According this taxonomy, this framework was proposed to add another feature of the proposed system, to manage the medical reviews of DS patients by sending a reminder message about medical tests (as well as their medical appointments). This feature will be describe in the conceptual design that will present in Chapter 4 later.

In conclude, this Chapter was proven that using framework will ensure to build a monitoring system that works by monitor health status of DS' patients according the vital signals that capturing by medical sensors. In addition, through the scheduling of the medical reviews by spending a reminder messages for responsible person of DS patients. These features of proposed system will expected to enhance the health status of DS' patients, means it expected to decrease the effective of the first independent variable of their health status.

Table 3.11 The Taxonomy of Providing Healthcare Services

Medical-review / test / diseases	Early detect	Routine (continuous)	Immediate (emergency)	Annual	
				1 year	2 years
Auditory testing of hearing Loss					✓
Vision tests (like: Ophthalmologic exam for keratoconus & cataracts)					✓
Evaluation of Sleep Apnea					✓
Heart tests (like: Echocardiogram)	✓	✓	✓		
Medical review for digestive disease	✓	✓	✓		
Dental reviewing (Twice)				✓	
Thyroid functions test	✓			✓	
Alzheimer checking (especially over 40 years old)				✓	
Blood disease test			✓	✓	
Infections test		✓	✓		
Obesity		✓			

One principle of business management is to divide the organization into specific departments. This principle has contribute controlling of business' organization, as well as for human resources [175]. In addition, the related works shows the role of information system to manage any organization by divided the activities of organization as a part or departments, to facility of manage these activities. Therefore, this framework was visualized the high level of DSIS as a layers. These layers will conduct according the similarity and integration of activities' sequence of it, and it will described in detail in Chapter 4 (Conceptual design of DSIS). Figure 3.20 below, shows the proposed layers of DSIS.

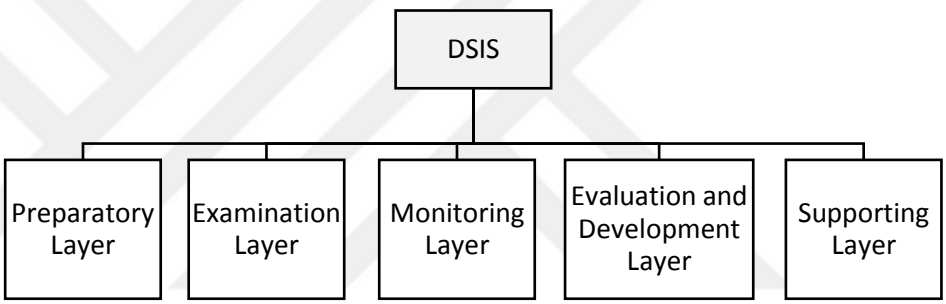

Figure 3.20 Proposed Layers of DSIS

CHAPTER 4

CONCEPTUAL DESIGN OF DSIS

According the conclusion of Chapter 3, DSIS was proposed to work for monitoring the health status of individuals with DS by using medical sensors, as well as managing medical reviews of DS patients by sending alarm messages to their responsible.

Therefore, this Chapter aims to describe the conceptual design of DSIS and visualize all its components. This means that Chapter will serve as a guide for developers to identify the technical requirements, participants and activities of DSIS. In addition, it will illustrate in detail how DSIS works by visualizing classes, attributes, operations, relationships between objects and the role of all participants in DSIS. This visualization will contribute in ensuring correct implementation of DSIS, which satisfy the main objective of this thesis.

According to TMC's recommendation, two developers from two different countries participated in this Chapter to ensure correct design and implementation of the proposed system.

In the beginning, the conceptual design of DSIS was created by identifying its components (technical requirements, participants and activities) for the whole system (for example, identify all participants of DSIS). In addition, use one use case diagram for visualize the whole DSIS (as shown in figure 4.1).

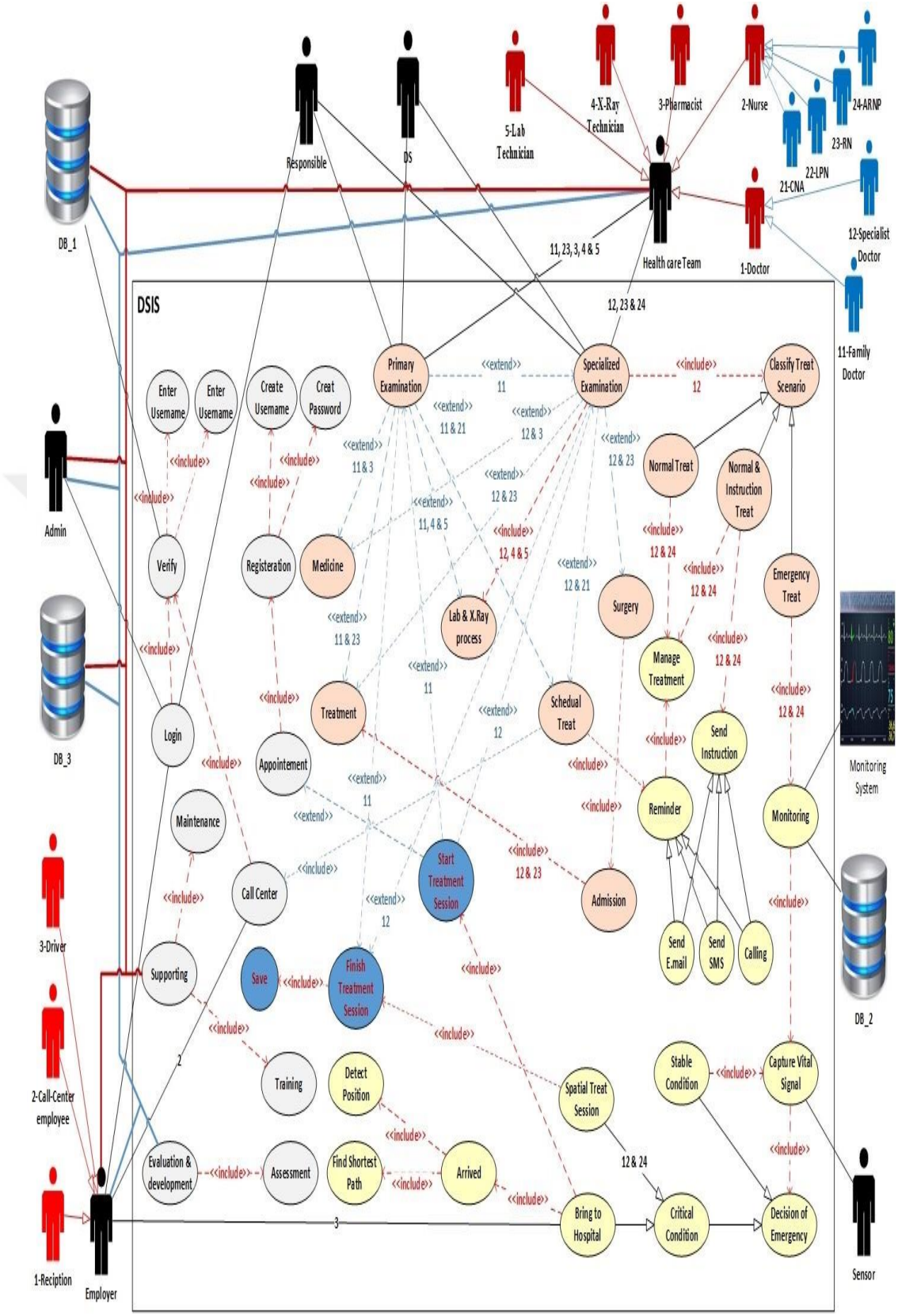

Figure 4.1 Use Case Diagram of Visualized the DSIS in the First Attempt

This conceptual design was presented to the first developer but it was refused for the following reasons:

1. The identified components for the whole DSIS leads to lack of determine the necessary components for each layer, which leads to an unclear conceptual design.
2. In general, the implementation of any system is conducted by different developers (according to specialty). Therefore, presenting DSIS in this way leads to overlap of work, which leads to weakness in implementing it.
3. Visualizing DSIS in this way leads to lack of focus to understand the DSIS' activities, which leads to poor implementation of this system.

Simultaneously, the second developer confirmed these the first, and all of them recommended the following notes on the conceptual design of DSIS, which will lead making it implementable in the future.

1. The conceptual design of DSIS must be conducted according to high-level structure (figure 3.20). This means that describe this system according this structure to make a conceptual scenario of each layer.
2. Identify the objectives of each layer in order to support the developer who is concerned with each layer to understand and implement its actions.
3. Identification of the main activities of each layer according to the consultation with some specialists. This will be the basis for identifying the requirements and participants of each layer.
4. Illustrate the activity-in detail of each layer according the main activities of it and visualize them by using flow chart diagrams.
5. Visualize each layer by using Use case diagrams to understand the behavior of DSIS from the users' perspective.
6. Summarize the activities of each layer as a table to support the developer to understand the layer's scenarios in the first view.
7. In addition, the TMC recommended some expect cases to illustrate the activities of examination and monitoring layers.

The flow chart in figure 4.2, shows the methodology of the conceptual design of DSIS.

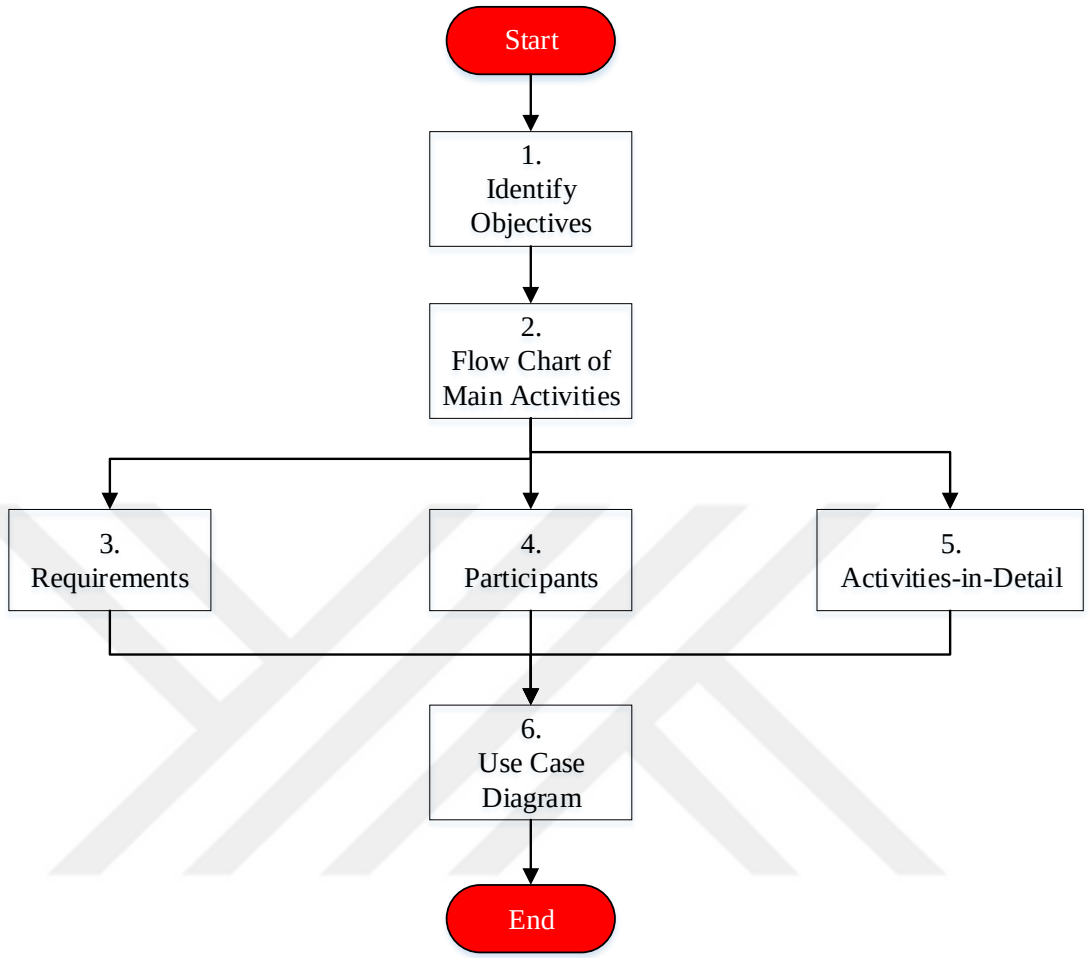

Figure 4.2 The Methodology of the Conceptual Design of DSIS

4.1 Scenario of Preparatory Layer

This framework suggests this layer as the first contact-point between DS and facilities of healthcare.

4.1.1. Objectives of Preparatory Layer

1) Increase the reliability, accuracy and validity of data transfer by relying on IT for registration processes. It means eliminating errors in data that are caused from potential errors or lack of information and reduce the time and effort of registration and treatment.

2) Support the end users by providing a call center for advice or assistance.

3) Increase the ability of communication among DS and healthcare providers.

4.1.2. The Flow Chart of Main Activities of Preparatory Layer

According of above objectives, figure 4.3 shows the flow chart about the main activities of preparatory layer, which will contribute to determining the requirements, participants and activities-in-detail in of this layer.

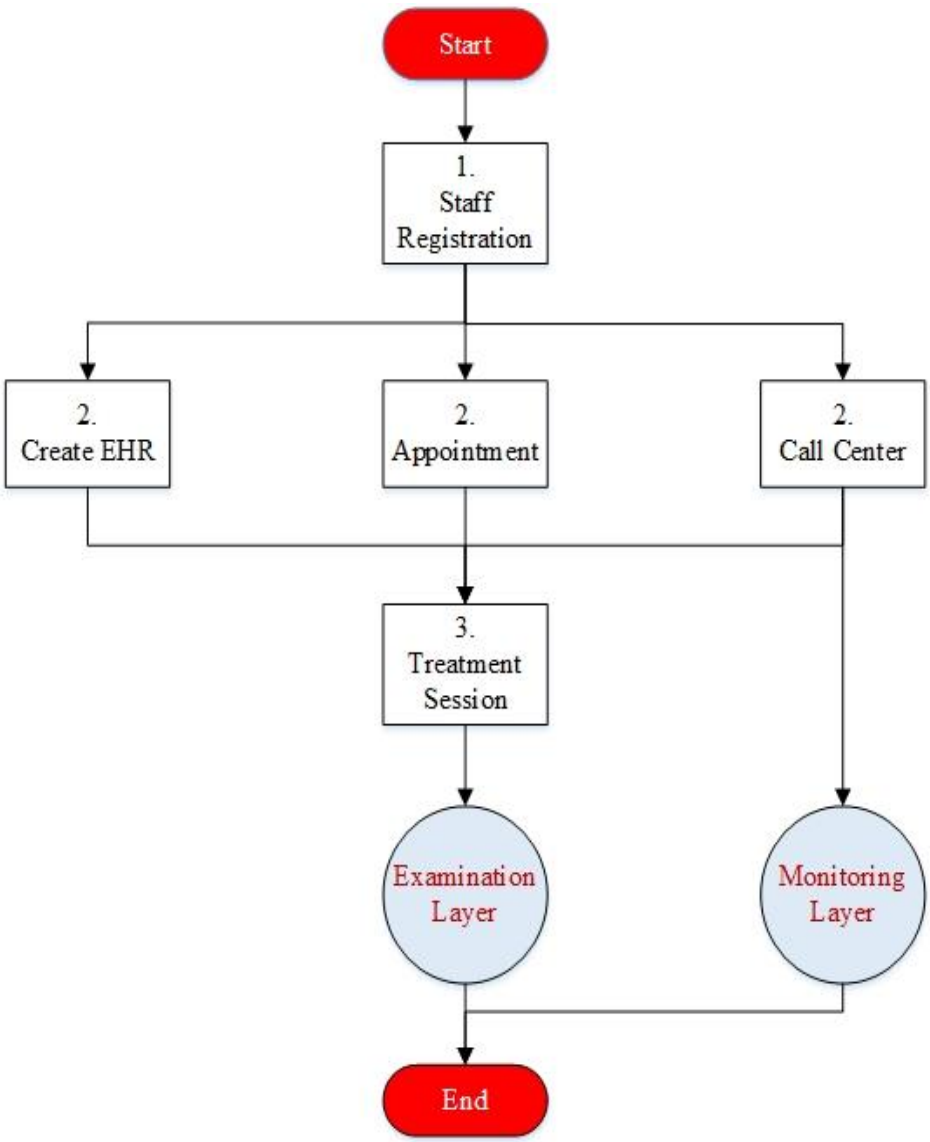

Figure 4.3 Main Activities of Preparatory Layer

4.1.3. Requirements of Preparatory Layer

Based on the main activities of preparatory layer (figure 4.3), the technical' requirements that will contributes to this layer are as follows:

1) PC's with all requirements, such as internet connections or web cam, to achieve the first objective of this layer.
2) Access card and card reader to accelerate DS admission to the hospital, and to achieve the first objective of this layer.
3) Special software with effective user interface and servers, to achieve the first and third objectives of this layer.
4) Mobile application for proposed system to achieve the first and third objectives of this layer.
5) Calling devices, to achieve the second and third objectives of this layer.

4.1.4. Participants of Preparatory Layer

According of main activities of preparatory layer (figure 4.3), the participants of this layer are as follows:

a) System staff who are responsible to manage the preparatory activities. They are:

    1) The receptionist, who is responsible to create a new EHR for DS. This employee should have skills in organization, good-communication and IT-usage.
    2) Family doctor, who is responsible to provide the medical recommendations through calling.
    3) An advanced registered nurse practitioner (ARNP), who is responsible to provide the medical recommendations instead of family doctor through calling.

b) End users are as follows:

    1) DS is the beneficiary of healthcare services.

2) Responsible people like DS' parents or any other. These people serve as a link between DS patients and the facilities of the healthcare services.

4.1.5. Activities-In-Detail of Preparatory Layer

According of main activities of preparatory layer (figure 4.3), the activities-in-detail are explained and they are furthermore summarized in the flow chart in figure 4.4.

a) Staff registration is an essential activity for employers, including healthcare staff. When there is a new registration, the system administrator is responsible to give an authentication code of this activity, and choose a login information for all system staff (username and password). Login to the proposed system is required for all staff who are to use this system. This activity contributes to satisfy the first objective by transforming it to an electronic environment.

b) Creating EHR for the end user (DS). It is the responsibility of the receptionist to create a new account for DS to be operated by their responsible people (in the first visit of DS patients). It starts by giving a specific form to be filled out by the responsible people, help them to identify username and password for later use, and save it in the central database for DS. In addition, make a smart card with personal photo of DS to use it in the next visit. Logging in to the proposed system through its mobile application is required for all responsible people who will use this system. This activity contributes to satisfy the first objective by transforming to the electronic environment.

c) Call center activity: This activity is responsible for transferring calls among all participants of proposed system, including the end user. In addition, it provides an automatic call center for all participants. This service can be used to support end user by providing instruction, and it can used to make an appointment. This activity contributes to satisfy the second objective of this layer.

d) Make an appointment: This is the one of the most important activities of this layer because it is important to make an examination session (except the emergency case). It starts by checking the information of DS (that is saved in the central database of DS) and make it according to the free schedule of healthcare teams. This activity can be implemented in several ways:

1) By doctor according of past examination.
2) Via a mobile application by a responsible person.
3) Via calling by a responsible person.
4) By direct connection with a medical facility via a receptionist.

This activity needs an EHR for a DS (meaning, it needs to be created first). Therefore, it contributes to satisfy objectives of this layer.

e) Treatment session: this is the final activity of this layer to start with an examination step. It is responsible to open a new medical session for DS and send it to the treatment staff (doctors and nurses). The proposed system is responsible to start this activity when the DS arrives and calls the EHR of DS to send it to the medical staff. The receptionist is responsible to perform this activity, or the responsible person can use a smart card reader to read a smart card of DS to start this activity. This activity contributes to satisfy the first objective of this layer.

Note:

As mention above, the database is not described because this conceptual design is focused on describing the activities of each layer, and there will be a detailed description of the database for the whole system in the implementation phase, which is recommend for future studies. This note applies also for the other layers that will be described in the following sections.

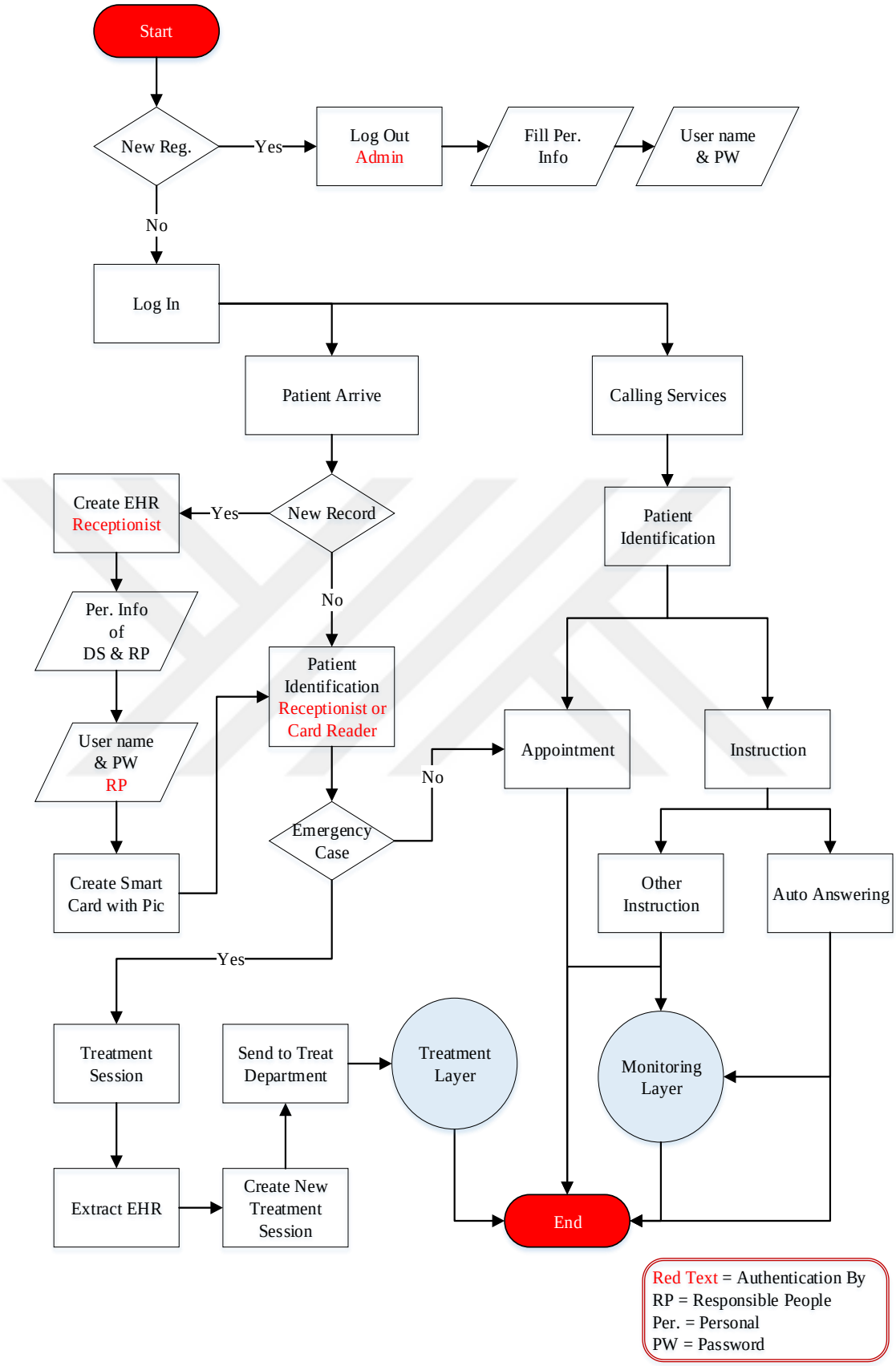

Figure 4.4 Flow Chart of Activity-in-Detail of Preparatory Layer

4.1.6. Use Case Diagram of Preparatory Layer

To satisfy the main objectives of proposed system (set a framework to design a DSIS), the use case diagram was suggested in order to visualize this layer from the perspective of participants. This diagram will depend on the main activities of this layer (figure 4.3).

In the beginning, the use case diagram was conducted as shown in figure 4.5 below.

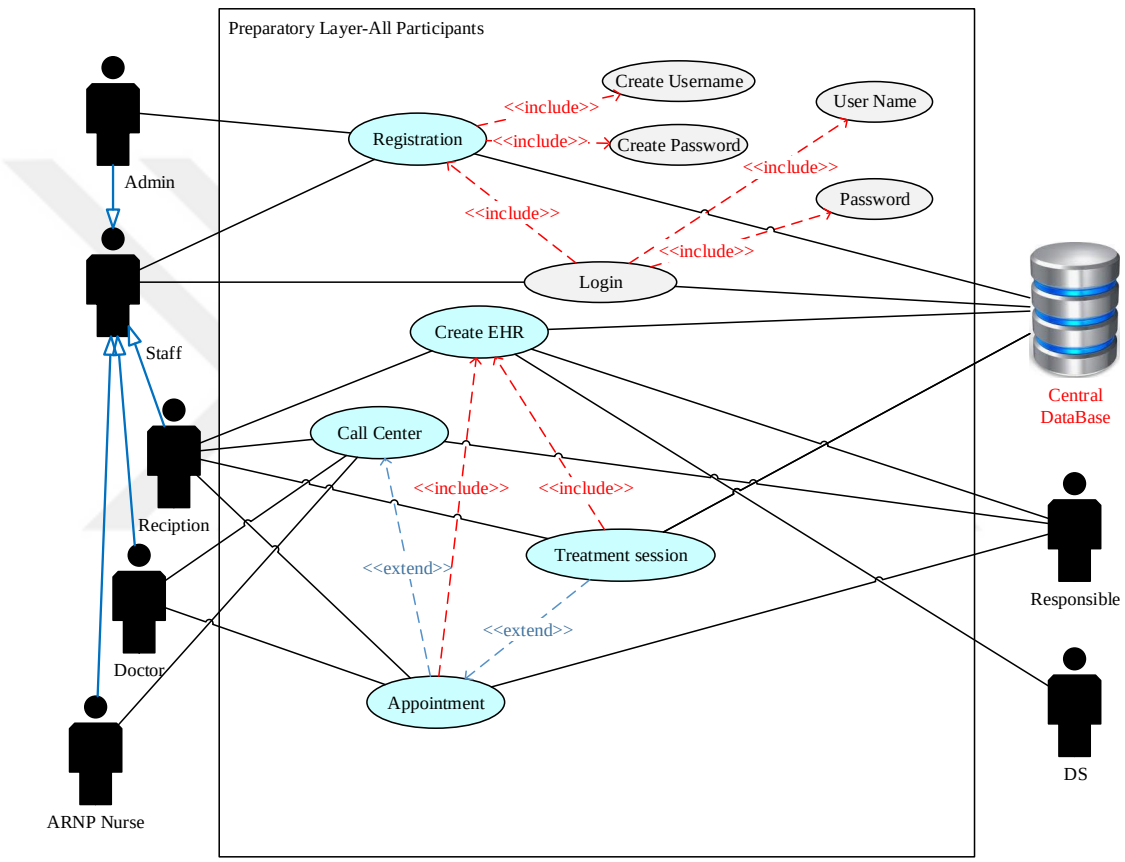

Figure 4.5 Use Case Diagram of Preparatory Layer-All Participants

The developers gave some other recommendations to make this diagram more clear by separate it according the type of participants.

Therefore, the participants of this layer are as follows:

1. System staff: all employers who are responsible for the functioning of the activities of this layer, including the administrators. Therefore, figure 4.6

shows the final version of the use case diagram of DSIS' staff of preparatory layer, which is described as follows:

a) The registration activity is a use case that responsible from system administrator, and it is necessary for all employers. Therefore, all of them are associated with it (as actors). According to the description in section 4.1.5, the administrator is responsible to give authentication to other actors to allow them to choose a unique user ID and password. In addition, a central database is a system actor to save all staff accounts.
b) All the staff need to login to the proposed system by using their user ID and password.
c) Create the EHR is a use case that responsible from a receptionist of DSIS. This use case is important for treatment session and appointment.
d) A call center is a use case that is responsible from a receptionist to support the end user needs, such as making an appointment and giving necessary instructions. Therefore, it shows the treatment staff (doctors and nurses) who are associated with this use case.
e) Making an appointment is a use case that responsible from a receptionist or doctor of DSIS. As shown in section 4.1.5, it needs the creation of an EHR first, but it is not important in emergency cases.
f) Treatment session is a use case diagram that responsible from the receptionist to start the treatment. As shown, the database use case is associated with it to extract the EHR of the patient.

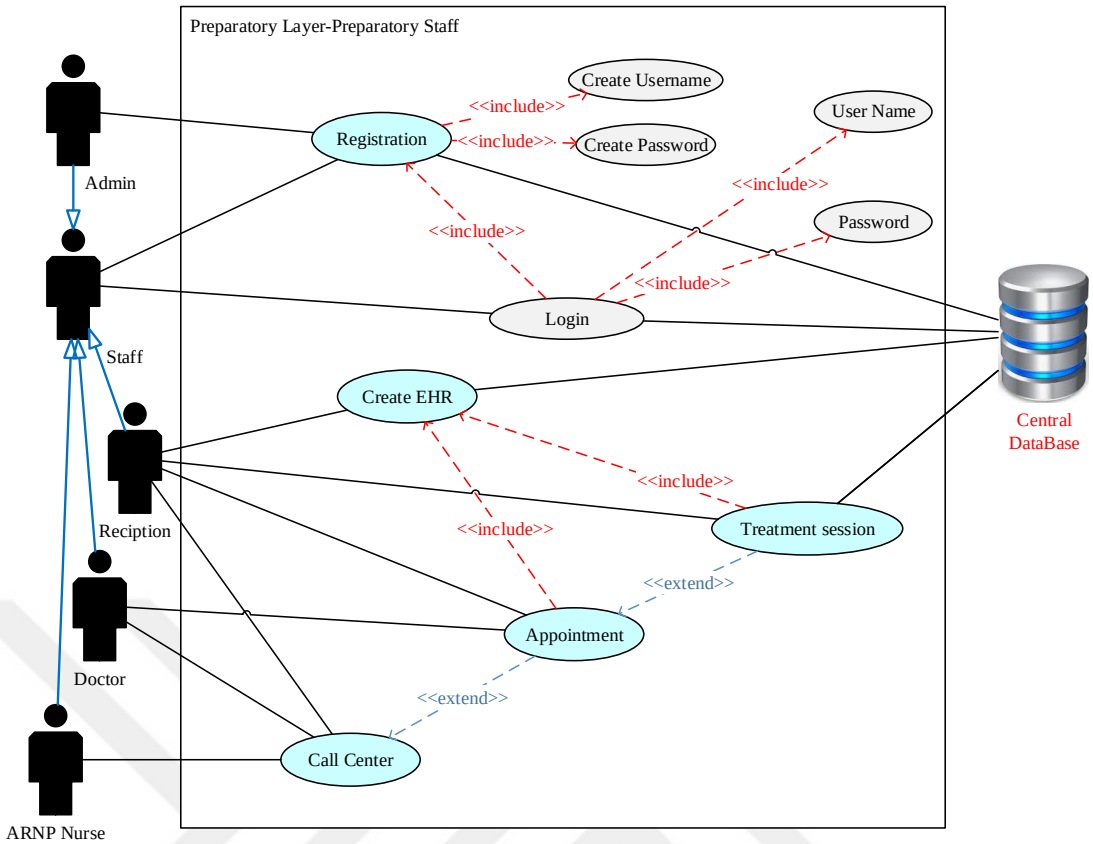

Figure 4.6 Use Case Diagram of System Staff of Preparatory Layer

2. End user: includes beneficiaries of DSIS (DS patients) and the persons' responsible for them. Therefore, figure 4.7 shows the final version of the use case diagram of DSIS' staff of preparatory layer, and it is described as follows:

   a) Create an EHR is responsible from the receptionist (as shown in figure 4.6). Also, DS patients and their responsible are associated in this use case.
   b) Responsible people are also associated with an appointment activity by calling or by direct connection.
   c) Responsible people are also associated with calling activities to get medical instructions or to make appointments.
   d) DS patients are associated with create an EHR with limitations to provide their picture.

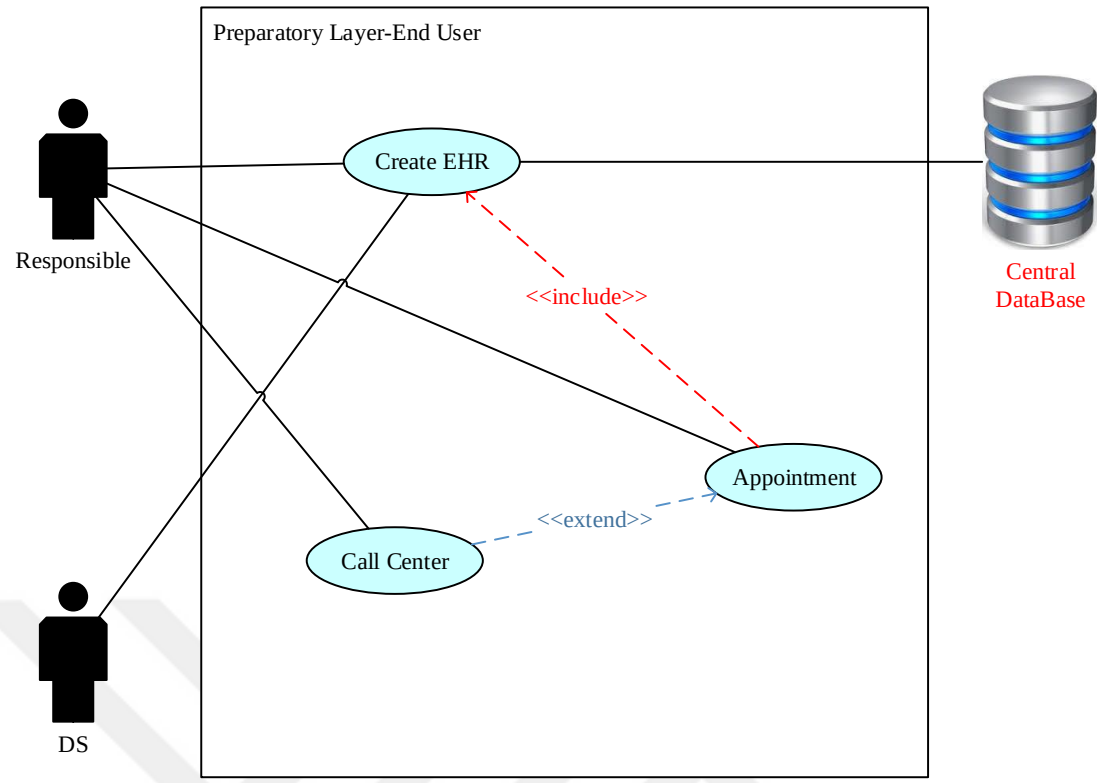

Figure 4.7 Use Case Diagram of End User of Preparatory Layer

4.1.7. Summary of Preparatory Layer

According on the recommendations of the developers, table 4.1 shows the summary of the preparatory layer. This table will support the developer to understand this layer on the first sight.

Therefore, this table presents a summary of this layer according its main activities, the activities-in-detail and the responsible of these activities.

Table 4.1 Summary of Preparatory Layer

Scene	Short description	Functionalities	Responsibilities
Staff Registration	This activity is responsible to make an account for all system staff to allow them to login to the proposed system.	Give authentication to logout.	Admin
		Full personal information.	Staff
		Choose user name and password.	Staff
		Login.	Staff
Create EHR	This activity is responsible for creating an EHR for all DS.	Check if DS have EHR.	Receptionist
		Full personal information of DS.	Receptionist + Responsible people
		Responsible people choose a user name and password to logout.	Responsible people
		Create smart card for DS.	Receptionist
Make appointment	This activity is responsible to make an appointment for DS.	Patient identification	System
		Make appointment	System
Call center	This activity is responsible to provide instructions for all callers, as well as to make an appointment.	Patient identification	System
		Instructions	System+ Receptionist
		Appointment	System
Create treatment session	This activity is responsible to make a treatment session for examination.	Check appointment.	System
		Extract EHR.	System
		Send to treat primary examination.	system

4.2 Scenario of Examination Layer

This layer serves to manage the provision of healthcare services for DS by systematically of transferring medical data among participants and departments of hospital, which leading to improved diagnosis and treatment of patients with DS.

4.2.1. Objectives of Examination Layer

1) Improve providing healthcare services by integrating all medical facilities.
2) Manage the provision of healthcare services by scheduling examinations and treatment reviews electronically.
3) Increase the role of responsible people and family doctors in providing health services for individuals with DS, by integrated them in treatment session.
4) Increase the reliability and accuracy of providing healthcare services by computerized system that works to customize a unique patient record for each individual and create an automatic classification of each treatment methods.

4.2.2. The Flow Chart of Main Activities of Examination Layer

According of above objectives, figure 4.8 shows the flow chart about the main activities of examination layer, which will contribute to determine the necessary requirements, participants and activities-in-detail of this layer.

Therefore, the main activities of examination layer are:

1) Primary examination to provide comprehensive health care services.
2) Specialized examination to diagnose health problems and make surgeries.
3) Classify treatment method of DS according of their health problems and taxonomy of medical tests of DS.

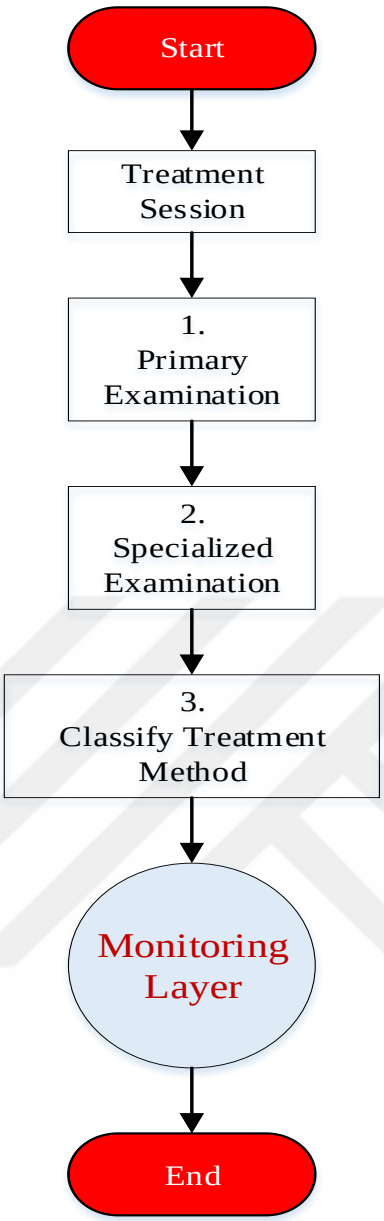

Figure 4.8 Main Activities of Examination Layer

4.2.3. Requirements of Examination Layer

According of main activities of examination layer (figure 4.8), the technical' requirements that will contributes in this layer are follows:

a) PCs with all requirements such as internet connections etc., to achieve the first objective of this layer.

b) Special software with effective UI and Servers, to achieve the first and third objectives of this layer.

4.2.4. Participants of Examination Layer

According of main activities of examination layer (figure 4.8), the participants of this layer are as follows:

a) Treatment staff who are responsible to provide healthcare services. They are as follows:

   1) Family doctor is responsible to provide comprehensive health care services for individuals over their live [176]. In other works, they are responsible to assess the DS' status by reading their medical history, make medical tests of them during the first visit or whenever it is necessary, send DS patients to specialist doctor to treat them according to the classified treatment method, and monitor their health status according on the recommendations of specialist doctor.
   2) Specialist doctor, who is responsible to classify the health status of DS patients and decide an optimal scenario for their treatment. In addition, they are responsible to perform surgeries whenever it become necessary.
   3) A Registered Nurse (RN), who is responsible to assist the family doctor to provide services by directly caring for the patients.

b) Assistants of treatment staff are as follows:

   1) Pharmacist, who is responsible to dispensing medicines.
   2) A Licensed Practical Nurse (LPN), who is responsible in lab and X-ray rooms.

c) End user are as follows:

   1) DS is the beneficiary of healthcare services.

2) Responsible people like DS' parents or any responsible person who will care for their child through their lives. These people are responsible to explain the state of their children to the doctors, transfer the reactions of their child to doctors, and follow the medical commandments.

4.2.5. Activities-in-Detail of Examination Layer

According of the main activities of examination layer (figure 4.8), the activities-in-detail are explained and they are furthermore summarized in the flow chart in figure 4.9.

a) Primary examination: this is the first step on the examination layer. It starts after creating the treatment session during the preparatory layer. The family doctor as well as RN and assistants of treatment staff are responsible for this activity to provide health services.

   Therefore, this framework described them as follows:

   1) Receive the treatment session that was created in preparatory layer. This session contains the EHR of DS, which was proposed by the system and sent it automatically to primary treatment staff.
   2) The proposed system schedules the patient's entry to the examination room accordingly.
   3) The EHR with all its details will be available to the family doctor.
   4) According on procedures proposed by the family doctor, the proposed system will do the following:

      i. Send treatment session to the lab or x-rays rooms if this is first the visit of DS, or when doctor needs.
      ii. Send treatment session to the specialist doctor if this is the first visit of DS, or when there is a need to re classify the patient's status or in the emergency case (when an alarm is sent by the classification layer as will be shown in the nest section).

iii. Send the treatment session to the pharmacy for Dispensing medicines.
iv. Make treatment with RN.
v. Arrange the next appointment.
vi. Finish the treatment session.

b) Specialist examination: this is the second step of examination layer. It starts after the treatment session is created from primary examination. The Specialist doctor as well as RN and assistants staff are responsible for this activity to provide health services. This framework described it as follows:

1) Receive the treatment session from family doctor. The proposed system sends it automatically when family doctor approves it.
2) The proposed system schedules patient's entry to the examination room accordingly.
3) The RN help the patient to enter to the examination room.
4) The EHR with all its details will be available to the specialist doctor.
5) According on procedures of specialist doctor, the proposed system sends the followings for specialist doctor.

i. Send EHR to the lab or x-rays rooms if this is first visit of DS, or when doctor needs.
ii. Make treatment of DS by adding or updating the diagnosis according to the integrated treatment codes within the proposed system.
iii. Send the EHR to the surgery room according to diagnosis.
iv. Send the EHR to the pharmacy room for Dispensing medicines.
v. Send EHR to the RN for medication.
vi. Finish the treatment session.

c) Classify Treatment methods for DS: The conclusion of Chapter 3 was that DS patients have huge and serious health problems. Therefore, this

framework proposed 4 scenarios to provide healthcare treatment for DS. These scenarios are:

1) Normal case scenario.
2) Normal case with some instruction scenario.
3) Treatment as needed scenario.
4) Emergency case scenario.

Indeed, this activity is one of the most important activities of proposed system. It can be act as separate layer but it was suggested as a part of the examination layer in the proposed framework because it must be within specialist doctor's responsibilities.

This framework suggests to add the treatment classification section in the EHR, which is one of the new features of this framework, and it will be managed by a specialist doctor. In addition, it suggests an automatic classification to achieve the first and fourth objectives of this layer, which means that the developer must create and integrate the classification section in EHR according the following parameters:

1) Type of diagnosis or health problems.
2) Increase health problems of DS patients.
3) Repetition the medical reviews of the same health problem.

Therefore, in the following, the description of them are as follows:

1) Classifying the treatment method of DS. This framework suggests making a decision, and the developer should build procedures according above parameters.
2) Classification method works automatically.
3) The specialist doctor approves the automatic classification, or changes it according their medical' skills.
4) The proposed framework should send an alarm of changes in classification to the family doctor or responsible people. This

procedure can support DS by detecting the new diseases or re assessing their health status accordingly.

5) The specialist doctor can decide to leave a medical sensor when the DS's condition is stable, by sending the patient to the monitoring layer to end monitoring session.

In accordance with the recommendation of TMC, some expected cases to illustrate the activities of this layer are shown below.

Case 1: Suppose the DS was classified as a first stage (normal case). After 5 reviews, the primary examination detects a high level of blood sugar test. Therefore, the classification procedures detect recurrence of this problem, which leads to a change in classification of the patient as someone with diabetes. This change is flashed to the family doctor as an alarm, which leads to sending the patient to the specialized examination for diagnosis and further assessment.

Case 2: Suppose the DS was classified as third stage and s/he temporarily uses a medical sensor a small heart problem, for instance. After 10 days, the medical sensor shows that the situation is stable according to the recommendations of specialist doctor. Therefore, the classification procedure detects that the health problem was eliminated, leading to a change in classification to stage two. These changes send an alarm to the responsible people via the monitoring layer to bring the DS for making a new examination.

Case 3: Suppose the DS was classified as third stage because of a small heart problem. After that, a specialist doctor of thyroid diagnoses a kind of thyroid disease and classifies separately as second stage. Because there is a correlation between heart and thyroid problem (according to the medical recommendations), the system detects this case by changing the classification to the fourth stage. Therefore, the system alerts the specialist of thyroid to convene a medical committee with heart specialists to further assess this case.

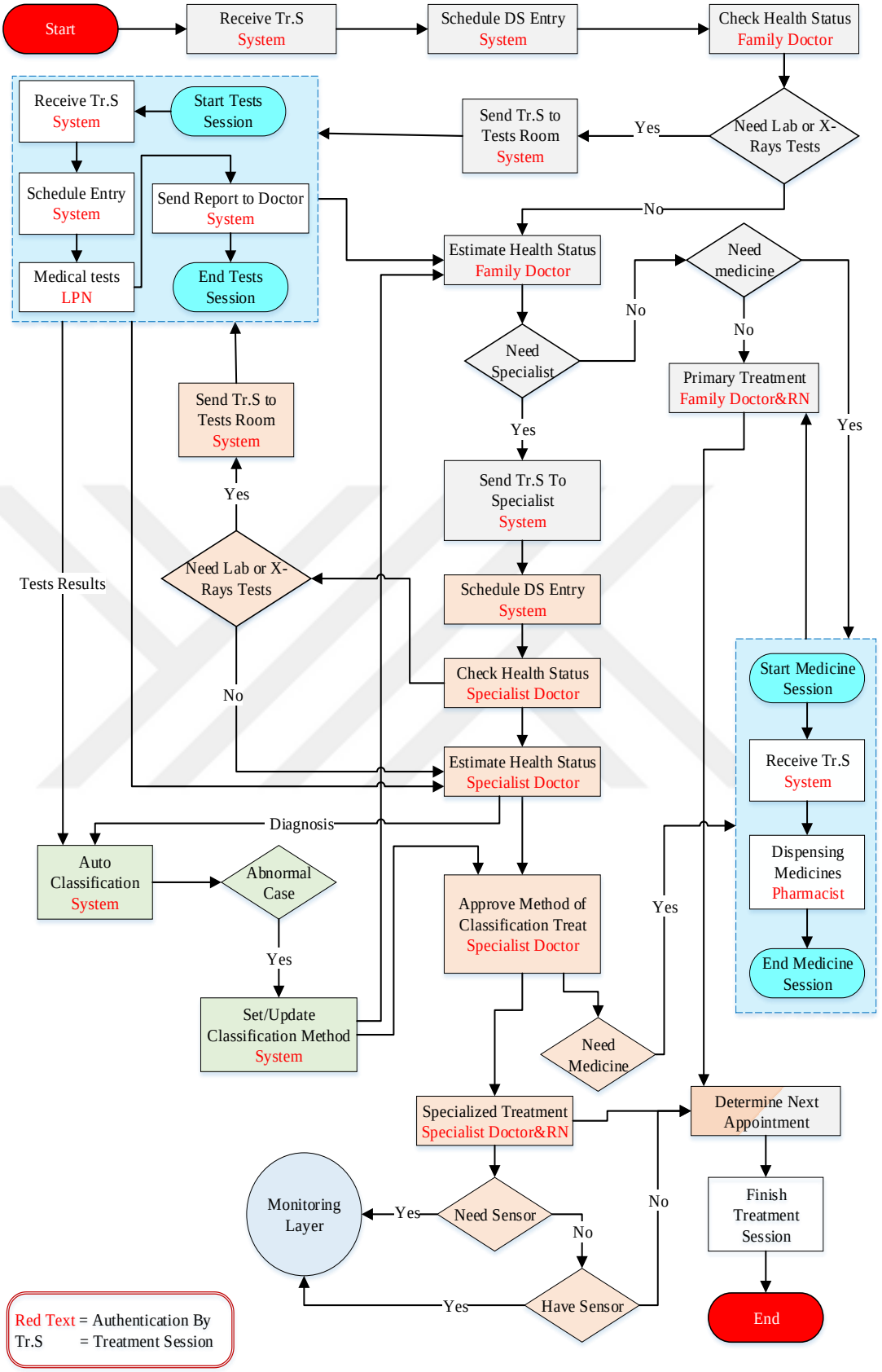

Figure 4.9 Flow Chart of Activity-in-Detail of Examination Layer

4.2.6. Use Case Diagram of Examination Layer

To satisfy the main objective of the proposed system (set a framework to design a DSIS), the use case diagram was suggested to show the roles of all participants in this layer. This diagram will depend according to the main activities of this layer (figure 4.8).

As shown in previous layer, in the beginning the use case diagram was conducted as shown in figure 4.10 below.

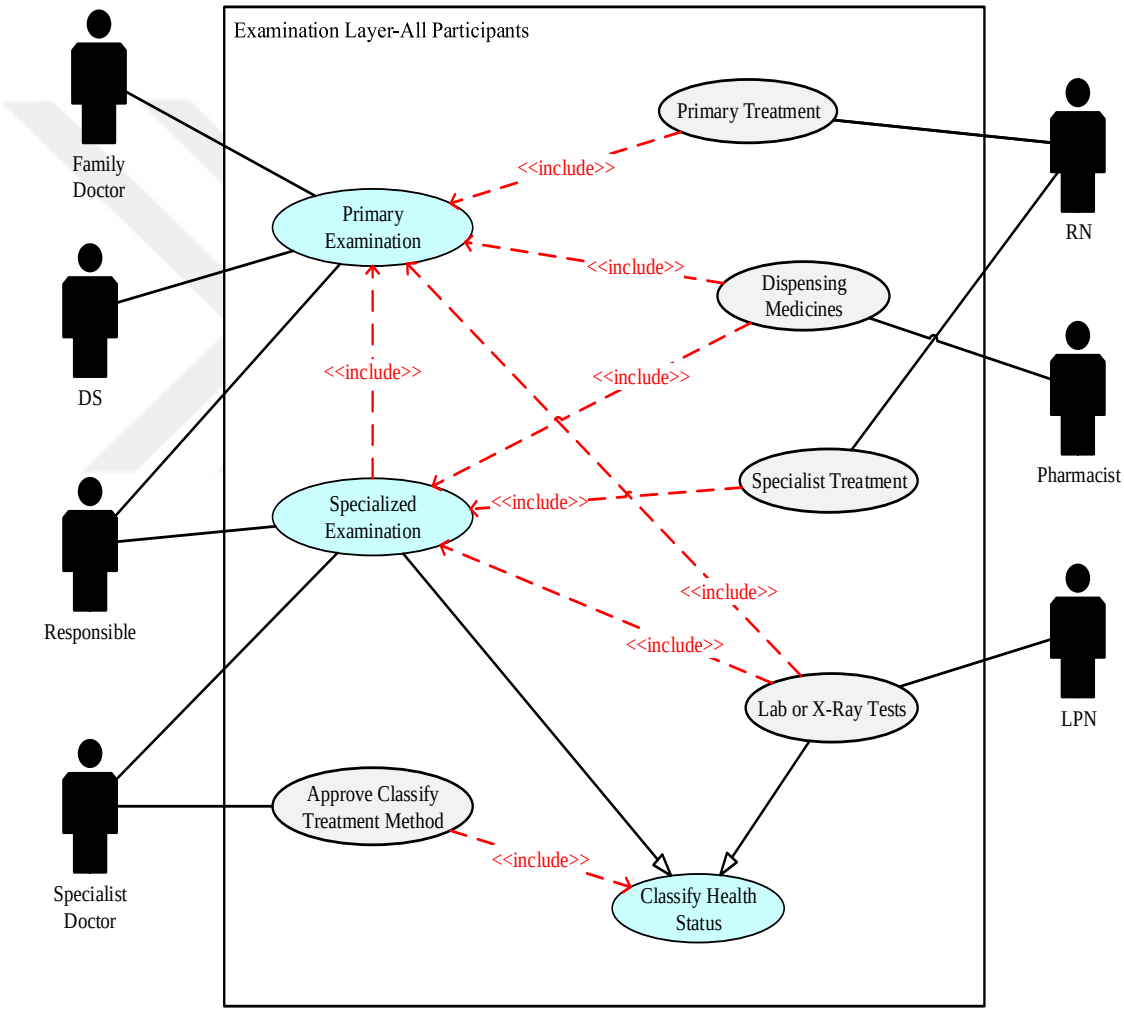

Figure 4.10 Use Case Diagram of Examination Layer-All Participants

The developers provided a set of recommendations to make this diagram more clear by separate it according the type of participants.

Therefore, the participants of this layer are as follows:

1. The treatment staff consisting of family doctor, Specialist doctor and RN their job is to provide treatment services
2. Assistant staff includes the pharmacist and LPN who help the treatment staff to provide healthcare services.

Therefore, figure 4.11 shows the final version of the use case diagram of treatment and assistant staff, and its description as follows:

a) The Family doctor is responsible for primary examination including all its details.
b) The specialist doctor is responsible for specialized examination including all its detail activities.
c) The proposed system is responsible of classifying the treatment methods automatically based on specialized examination or results of medical tests.
d) The specialist doctor is responsible of approving the classification treatment method. This is sub-activity of classification treatment method.
e) The family doctor is responsible of primary treatment, which is sub-activity of primary examination. This duty is also shared by the RN.
f) The pharmacist is responsible for dispensing medicines, and for this, permission from primary or specialized examination is needed.
g) The specialist doctor is responsible for specialize treatment, which it is sub-activity of specialist examination. This duty is also shared with RN.
h) The LNP nurse is responsible for lab or X-ray tests, and for this, permission from primary or specialized examination is needed.

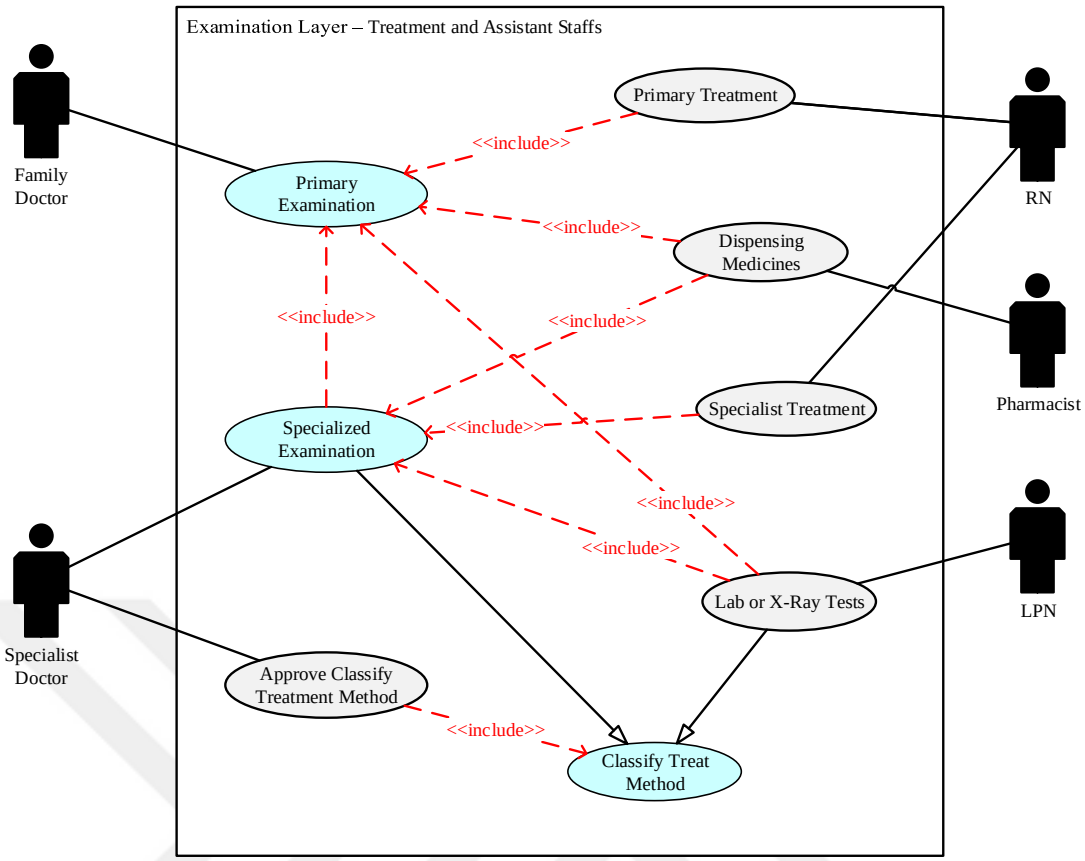

Figure 4.11 Use Case Diagram of Treatment and Assistant Staffs

3. End user: It includes beneficiaries of DSIS (DS patients) and the persons responsible for them. Therefore, figure 4.12 shows the final version of the use case diagram for the end user examination layer, and it is described as follows:

   a) DS is sharing with primary and specialized examination to give the vital data. Means, as a beneficiary of this activity.
   b) Responsible people have semi responsibility for the primary and specialized examination. They are beneficiaries who translate symptoms of their children.
   c) All sub-activities shown in figure 4.12 prove that the responsible person for DS patients will sharing to work with this layer.

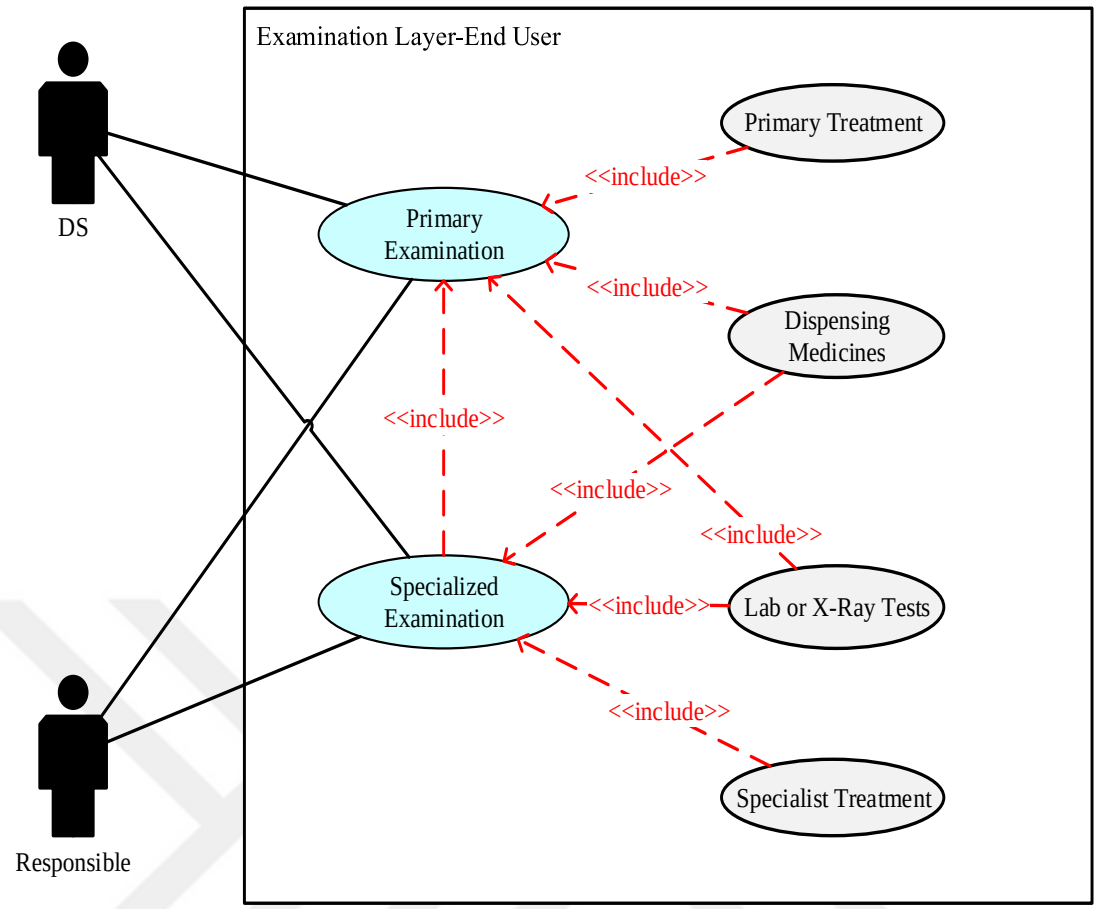

Figure 4.12 Use Case Diagram of End User of Examination Layer

4.2.7. Summary of Examination Layer

According on the recommendations of the developers, table 4.2 shows a summary of the examination layer. This table will support the developer to understand this layer on the first sight.

Therefore, this table presents a summary of this layer according its main activities, the activities-in-detail and the responsible of these activities.

Table 4.2 Summary of Examination Layer

Scene	Summary	Functionalities	Responsibilities
Primary examination	Primary examination contributes to provide healthcare services in general, and follows the patient's condition continuously, and send patients for to specialist examination if they need **Notes:** **TrS = Treatment Session** **MT = Medical Tests** **FD = Family Doctor** **SD = Specialist Doctor**	Receive TrS	System
		Scheduling entry	System
		EHR appear	System
		Send TrS to MT	System
		Medication	FD+RN
		Send TrS to pharmacy	System
		Send TrS to SD	System
		Arrange appointment	System+FD
		Finish TrS	System
Specialized examination	Specialized examination contributes to exact diagnosis of disease and determines the optimal method of treatment by classifying treatment method	Receive TrS	System
		Scheduling entry	System
		EHR appear	System
		Send TrS to MT	System
		Medication	SD+RN
		Send TrS to pharmacy	System
		Arrange appointment	System+SD
		Finish TrS	system
Classify treatment method	It works to make auto classification according to medical tests, diagnosis, and number of reviews. The specialist doctor approves it according on his skills. The system sends alarm if it changes.	Auto classify	System
		Approved	SD
		Send alarm	System

4.3 Scenario of Monitoring Layer

The aim of this layer is to enhance health status, by monitoring and managing the provision of healthcare services by investment in IT.

4.3.1. Objectives of Monitoring Layer

1) Monitor the health status of DS.
2) Manage scheduling of examination reviews.
3) Increase the connection among DS and healthcare facilities by invest on IT to manage this layer.

4.3.2. The Flow Chart of Main Activities of Monitoring Layer

According of above objectives, figure 4.13 shows the flow chart for the main activities of monitoring layer, which will contribute to determine requirements, participants and activities-in-detail of this layer. These activities are as follows:

1) Monitor health status of DS by medical sensors.
2) Manage schedule of medical reviews for DS by sending messages.

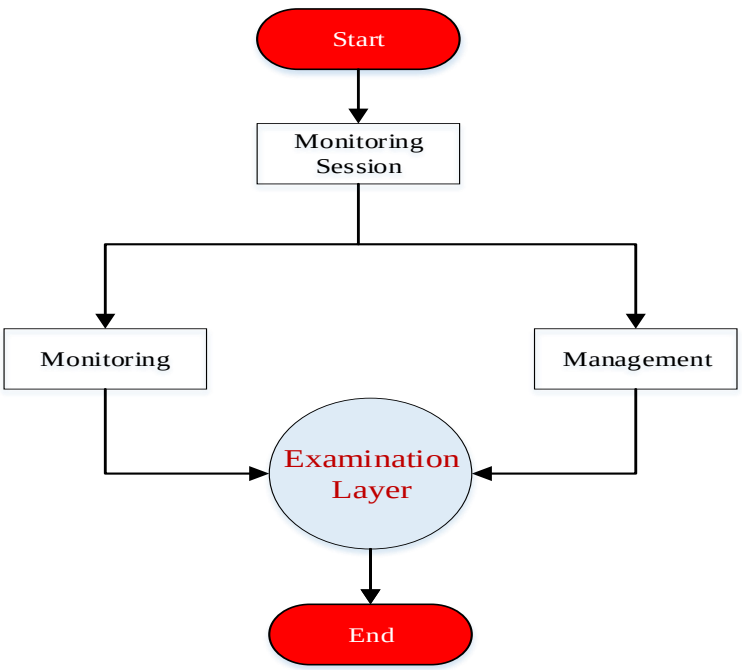

Figure 4.13 Main Activities of Monitoring Layer

4.3.3. Requirements of Monitoring Layer

According of main activities of monitoring layer (figure 4.13), the technical requirements that will contributes in this layer are follows:

a) PCs with all requirements and communication devices.
b) Special software with effective UI and Servers.
c) Wireless Wearable device recommended by the specialist doctor to be integrated with medical sensors in order to capture and send vital signals wirelessly to the medical center [177, 178]. Therefore, it consists of two tiers.

    1) Biosensors to capture vital signals of DS.
    2) Gateway to transfer vital data via internet connections like Global System for Mobile communication (GSM) network.

d) Ambulance to reach the DS in emergency cases.

4.3.4. Participants of Monitoring Layer

According of main activities of the monitoring layer (figure 4.13), the participants of this layer are as follows:

a) Monitoring staff who are responsible for monitoring and managing the health status of DS, they are as follows:

    1) Doctor, like family doctor to identify and make decision about the emergency case, and provide health instructions.
    2) ARNP, these nurses work instead of doctor when the later is absent. They responsible for identifying and making decisions about the emergency cases, and provide health instructions. As well as, setting up sensors for DS.

b) Paramedics staff to provide first aid services or bring DS to hospital. They are as follows:

1) A Clinical Nurse Specialist (CAN) to provide first aid services.
2) Ambulance driver to help CAN to bring DS.

c) The end users as follows:

1) DS is a beneficiary of healthcare services.
2) Responsible people like parents, to receive messages about medical instructions, or reminders messages about medical appointments for their childs.

4.3.5. Activities-in-Detail of Monitoring Layer

According of main activities of monitoring layer (figure 4.13), in the following the activities-in-detail of this layer.

a) Monitoring health status of DS

This new feature was proposed in this framework. It starts when the specialist doctor decides to use certain medical sensors to estimate the DS' health status online. These sensors are working to make decisions automatically under the recommendation of specialist doctor. Therefore, it described as follows:

1) Create a monitoring session

This is the first activity of monitoring layer. It starts automatically when the specialist doctor decides to use a sensor for DS. This session accordingly creates the information in EHR and saves it in the medical web server. Therefore, it contains the following pieces of information:

i. Personal information of DS.
ii. The sensor ID recommended by specialist doctor.
iii. Section to save abnormal vital signals.
iv. Monitoring recommendations.

This means that the DSIS is responsible to start this activity.

2) Sensor setup

After creating a monitoring session, ARNP is responsible to setup the sensors recommended from the specialist according to the type of disease. For example, the heart rate sensor is used to capture the systolic and diastolic blood pressures, as well as heart rate. Therefore, ARNP set this device according the recommendations of the specialist doctor.

3) Capturing vital signals is one of the most important activities of remote monitoring system. It works according of the type of sensors and doctors' recommendation. For example, the heart rate sensors work 4 times per day. This activity works in the first tier of wearable device, and the proposed system is responsible of it.
4) Abnormal signals are detected if the captured signal is out of the range set by ARNP.
5) Send vital signals to the medical web server via GSM as a text message. This message contains sensor ids to identify abnormal signals, time, and the GPS of DS patients. The proposed system suggests using one of the web protocols such as XMPP[1] networks to send these signals to ensure data security.

Figure 4.14 below shows an example of the structure of the sensor's text message to estimate heart rate. In the figure, HR stands for heart rate, SBP for systolic blood pressure, DBP for diastolic blood pressure, and GPS for global positioning system.

Sensor ID	Time	HR	SBP	DBP	GPS

Figure 4.14 Structure of Message of Heart Rate Sensor

[1] Extensible Messaging and Presence Protocol (XMPP) is a communication protocol to transfer messages at the real time. It based on XML language to support message-oriented middleware [179].

6) Decision the health status of patients: This activity is responsible for checking the text message sent by sensor and make an automatic decision about it. The web[2] server and monitoring staff are responsible of this activity. Therefore, it consists of the following:

i. If the signal is normal, it means this is consider stable, and the next signal is captured (step 3).
ii. If signals or their means not on the range, send alarm message to the monitoring staff (step iii or iv).
iii. Monitoring staff reject the alarm message according their skills. In addition, they can send recommendations as alarm message to the responsible person (Figure 4.15a), and continue to capture the following vital signals (step 3).
iv. Monitoring staff approves the alarm messages according their skills, and write monitoring recommendations. This means that they decider it as a critical case, and send this alarm to create a paramedic session (step 7).
v. Send alarm messages to paramedic staff and responsible person. These messages contain information about their duties. Therefore, the proposed system sends 3 alarm messages as shown in figure 4.15 below.

Personal info. Of DS	Recommendation

Figure 4.15a Structure of Alarm Message to Responsible Person

Personal info. Of DS	Medical recommendation

Figure 4.15b Structure of Alarm Message to Paramedic' Nurse

Personal info. Of DS	GPS

Figure 4.15c Structure of Alarm Message to Drivers

[2] The web server decides if the abnormal message shows a critical case or not by comparing it with the past signals.

7) Create a paramedic session. This activity is responsible for bringing DS to the hospital. It starts automatically when the monitoring staff approves the alarm message. This session is created in accordance with EHR and alarm messages. Therefore, it contains the followings:

   i. Personal information of DS.
   ii. CAN nurse and driver ID
   iii. Spatial position of DS.
   iv. Medical recommendations.
   v. Departure and arrival times.

8) Arrive to DS. This activity is responsible bring the medical staff to the DS patients according to their positions. The proposed system uses an algorithm to calculate the shortest path to reach the DS. For example, system defended by the author, which incorporates Dijkstra algorithms can be modify to work with this system [180].
9) End paramedic session. This applies when the paramedic staff arrives to the hospital. The examination session will start again, and the paramedic session will finish.
10) End monitoring session. The proposed framework suggests to end this session when the specialist doctor recommends it. This happens when permission from an examination layer to end this monitoring session is obtained and the ARNP uninstalls the wearable devices, and approves it to allow the proposed system to store this session.

b) Managing schedule of medical reviews. The proposed system suggests sending reminder messages to the responsible person about the medical review according on the appointment time.

Therefore, this framework described this activity in detail as follows:

1) Create an enquiry table based on appointments in the EHR. i.e., arrange table according the appointment time.

This enquiry consists of the following columns.

i. EHR ID
ii. DS' patients Name
iii. Responsible person's Name.
iv. Time of Appointment.
v. Family Doctor ID.

2) Send a reminder message of the nearest appointment to the responsible person. For example, the proposed system sends a reminder message 7 days before the appointment.

The propose system suggests sending SMS or email messages to responsible people, or both of them.

3) Retry sending a reminder message 1 day before appointment.

According the recommendation of TMC, in the following some expected cases to illustrate the activities of this layer.

Case 1: In case the wearable device is used for the first time, suppose the specialist doctor decides to use a medical sensor to monitor the blood pressure of DS for 15 days. Then, he suggests using a wireless wearable device to estimate the blood pressure and heart rate. Then, the proposed system works according the following steps:

1. Create a monitoring session that contains information about DS patient and their responsible person, ID of the wearable device, and a section for medical recommendations that are sent to the monitoring staff or to the responsible person. In addition, section to store abnormal systolic and diastolic blood pressure as well as heart rate is created as well.
2. Installing and operating the medical sensors on patient's body by ARNP.
3. The ARNP setting the measurement range of the medical sensors according the recommendation of doctor. For example, the range of the systolic and diastolic blood pressures is between 120 to 140, and 80 to 90

respectively, while the heart rate is 60 to 100 beats per minute, and any measurement outside this range will be considered as abnormal signals.

4. The wearable device captures vital signals and send abnormal signals to the web server through a gateway of this device.

Case 2: In order to capture the daily vital signals, suppose the specialist recommends capturing blood pressure 4 times in a day for 10 days and after that period makes a decision on the health status by calculating the average of blood pressure. Therefore, the conclusions are:

1. If average is in range, go to capture another 10 days.
2. If average is out of range, send an alarm message to the doctor to make a decision by sending a recommendation to the responsible person or make a new appointment.

Case 3: For a critical case, suppose the specialist doctor suggests using a wearable device to monitor of heart signals and estimate the cardiac electrical activity and heart sounds (Electrocardiogram sensor (ECG). Therefore, the proposed system works as following:

1. If the ECG is out of the range, then the section responsible for decisions of health status activities creates an alarm message and sends it to the monitoring staff.
2. If they approve this alarm, a paramedic session is created by sending a paramedic message to drivers and CAN to bring the patient in. In addition, the shortest path is provided to the driver to arrive to the patient as quickly as possible.
3. If the specialist doctor suggests using this wearable device for 1 month, and in the next appointment decided to leave it, he sends the DS to the monitoring layer to end the monitoring session and store it on the monitoring section of the web server.

Figure 4.16 below shows the flow chart of activities-in-detail of monitoring layer.

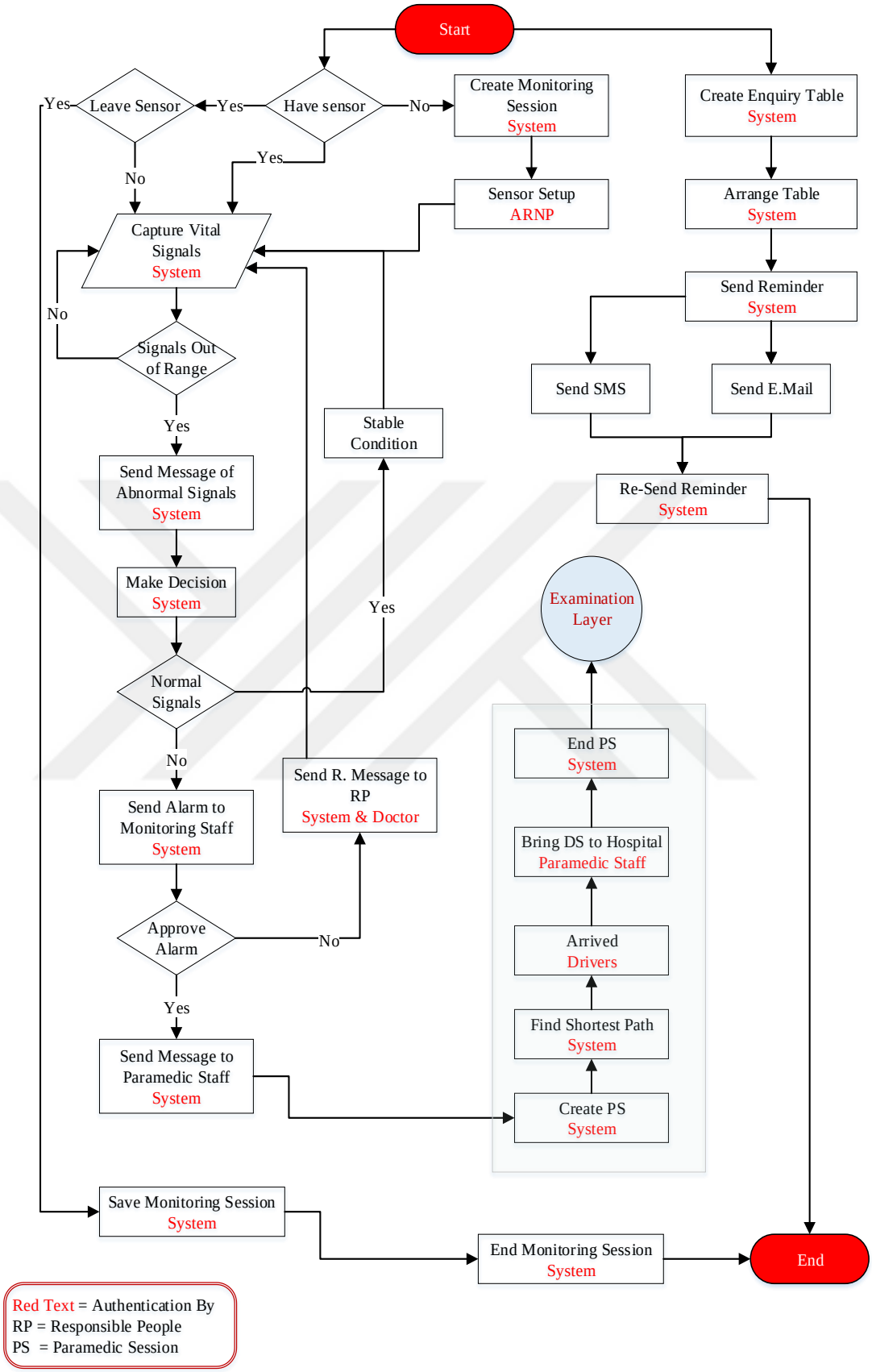

Figure 4.16 Flow Chart of Activity-in-Detail of Monitoring Layer

4.3.6. Use Case Diagram of Monitoring Layer

To satisfy the main objective of proposed system (set a framework to design a DSIS), the use case diagram was suggested to show the roles of all participants in this layer. This diagram will depend on the main activities of this layer (figure 4.13).

According to the recommendation of the developers, the use case diagrams for this layer was done according the type of participants whose responsibilities are as follows:

1. Monitoring staff of monitoring activities is a new feature proposed for DS patients, and it works by tracking changes of medical sensors to detect the critical cases. Figure 4.17, shows this diagram with its detail as follows:

    a) The proposed system is responsible for creating a monitoring session, which needs permission from a specialist doctor.
    b) The ARNP nurse is responsible for setting sensors by installing and operating them according the recommendation. In addition, ARNP needs permission from the specialist doctor to use such medical sensors.
    c) The proposed system is responsible for capturing vital signals by medical sensors, which need to be setup first.
    d) The proposed system is responsible for making decisions about the health status automatically, and for this it needs capture vital signal first according the sensor setting by ARNP and decided whether. The readings are stable or abnormal.
    e) The Doctor is responsible to give permission to the ARNP to use the medical sensors. In addition, the doctor is also responsible for differentiating abnormal conditions after decisions from the medical sensors are made reject or approve of decision.

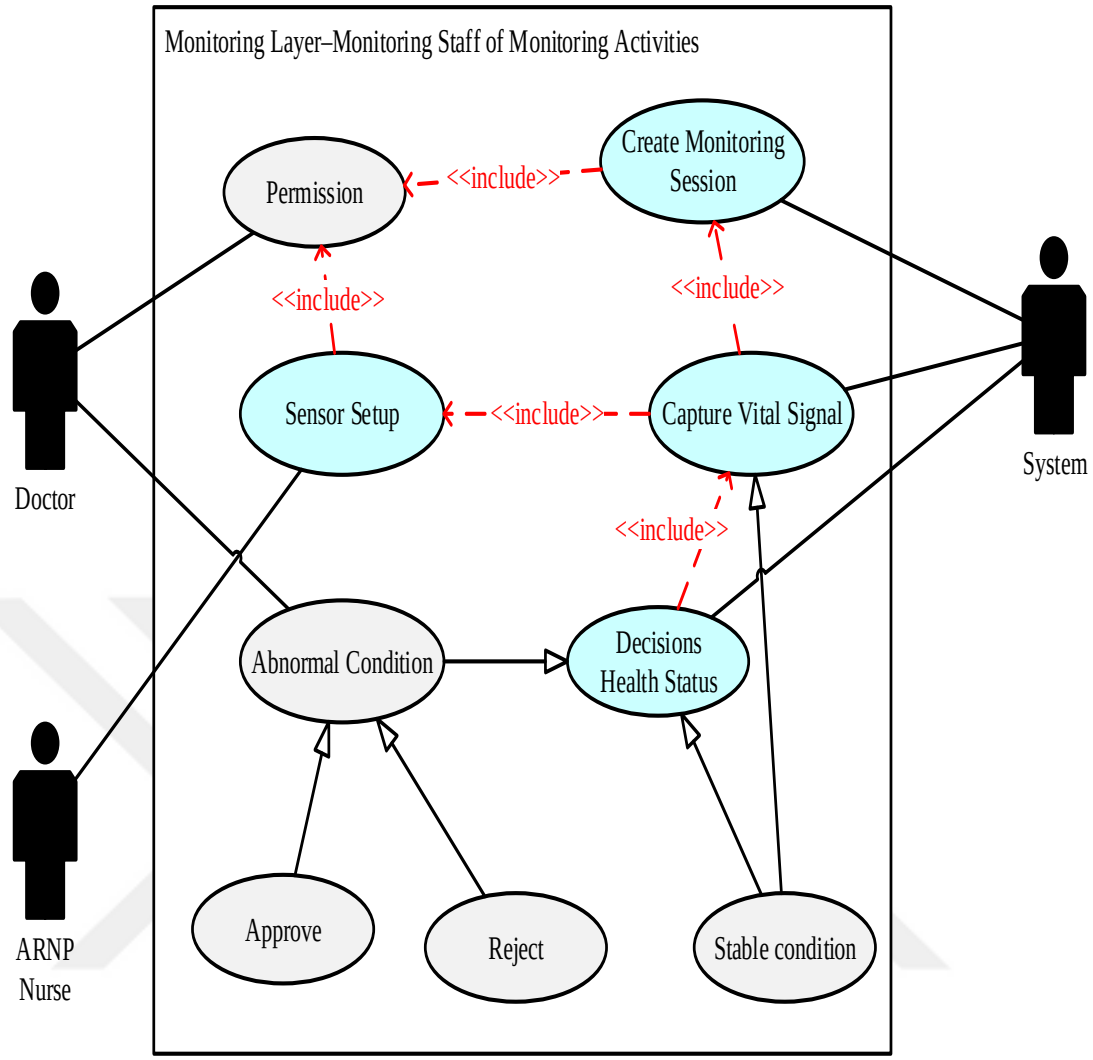

Figure 4.17 Use Case Diagram of Monitoring Staff in Monitoring Activities

2. Paramedic staff of monitoring activities starts to work within the proposed system when the get permission from the specialist doctor (in case the abnormal condition is approved). Figure 4.18 shows this diagram and its detail are as follows:

   a) The paramedic staff starts to work within the proposed system when they receive permission from a doctor who has in turn approved the abnormal condition (as shown in figure 4.17 above).
   b) The proposed system is responsible for creating a paramedic session automatically and send a message to CAN nurse and driver.

c) The proposed system is responsible to calculate the shortest path to the DS patient's position.

d) The driver is responsible for arrive to the position according the shortest path.

e) The CAN nurse is responsible for providing the first aid to DS.

f) The CAN and driver are responsible for bringing DS patient to the hospital and create a new examination layer.

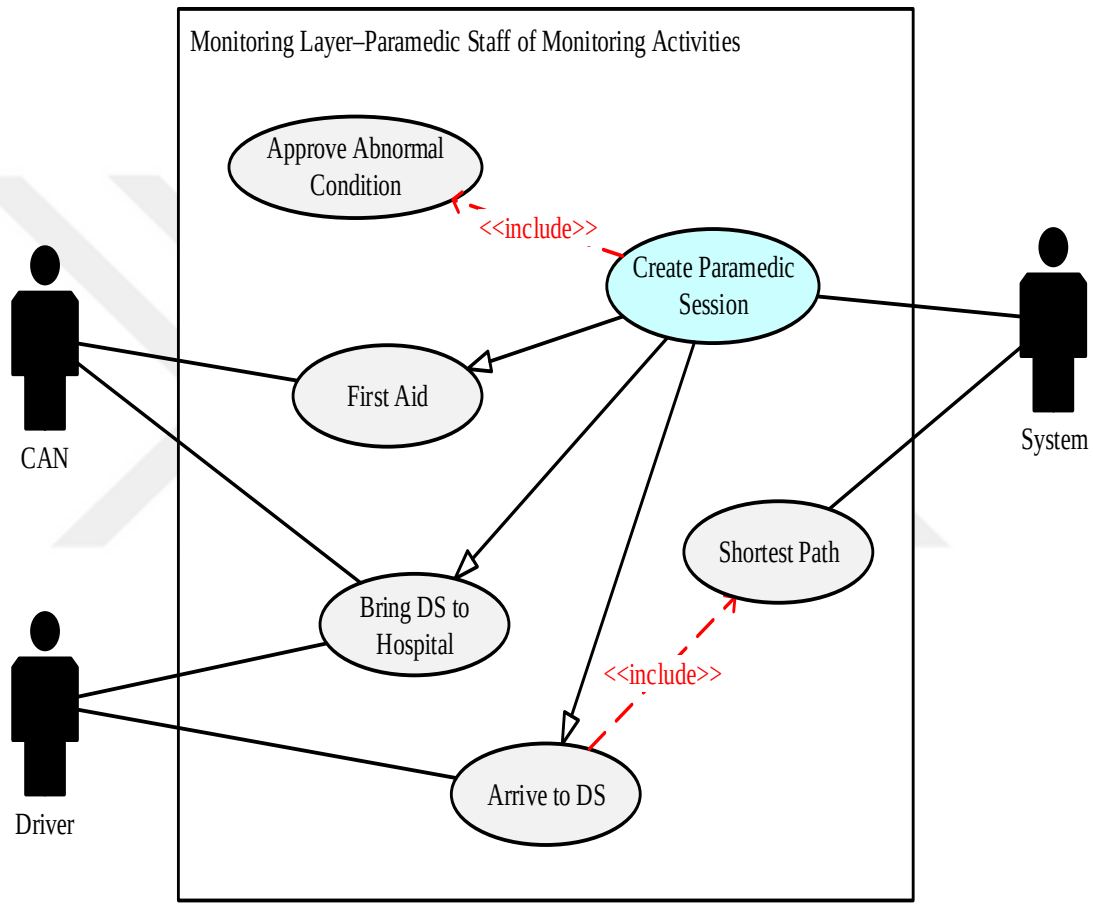

Figure 4.18 Use Case Diagram of Paramedic Staff in Monitoring Activities

3. End user of monitoring activities includes beneficiaries of DSIS (DS patients) and their responsible for them. Therefore, figure 4.19 shows the final version of this diagram and its detail are described as follows:

a) The DS patients is part of this by giving their vital signals and it shows that they do not have any other responsibility within the DSIS.

b) The responsible peoples' part in this layer is sharing with ARNP by help their child to set the medical sensors.

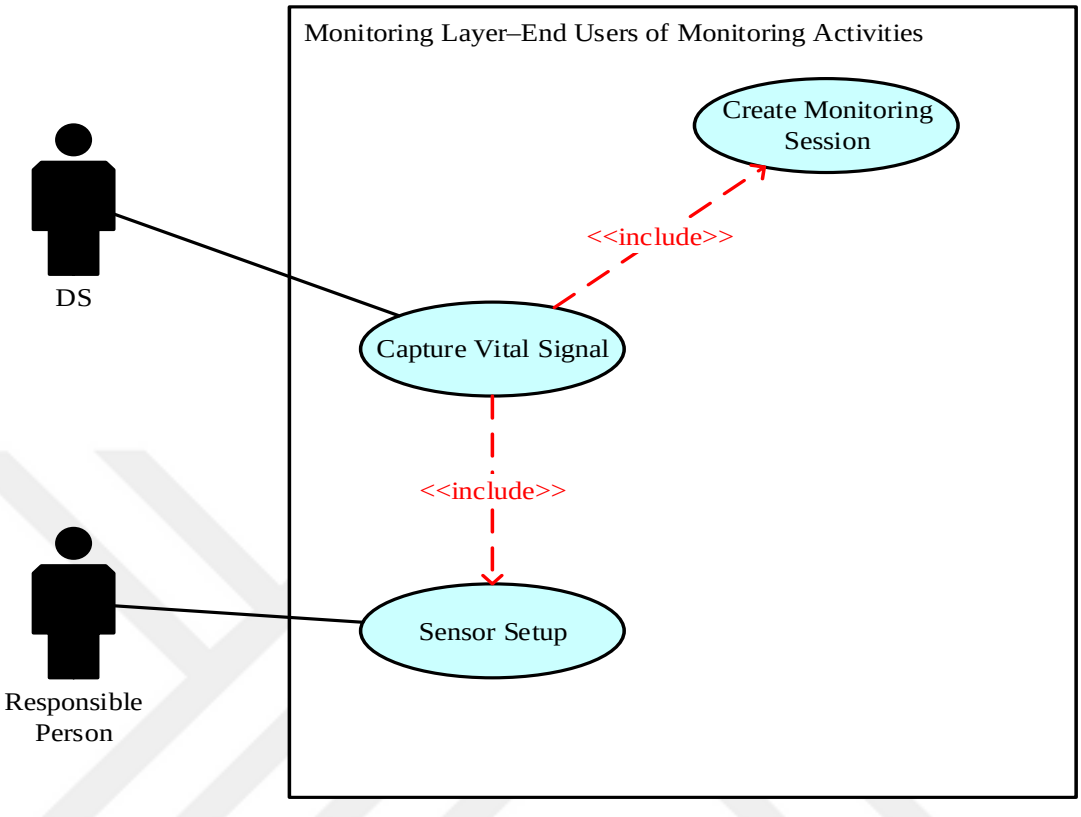

Figure 4.19 Use Case Diagram of End Users in Monitoring Layer

4. All participants in management activities have a role in managing the medical reviews of DS patients. Therefore, figure 4.20 shows the final version of this diagram and it's details are described as follows:

a) The proposed system is responsible for creating an enquiry table about the EHR automatically and update it over time. This enquiry consists of information as present in section 4.3.5./b above.

b) The proposed system is responsible for arranging the enquiry table according to date and time. This activity needs to be updated over the time and create an enquiry first.

c) The proposed system is responsible for sending a reminder message automatically, for example 7 days before the appointment and resend

this message 1 day before as well. The reminder message can be sent by SMS, e-mail, or both.

d) The use case diagram shows that the proposed system has a full responsibility to manage the medical reviews of DS.

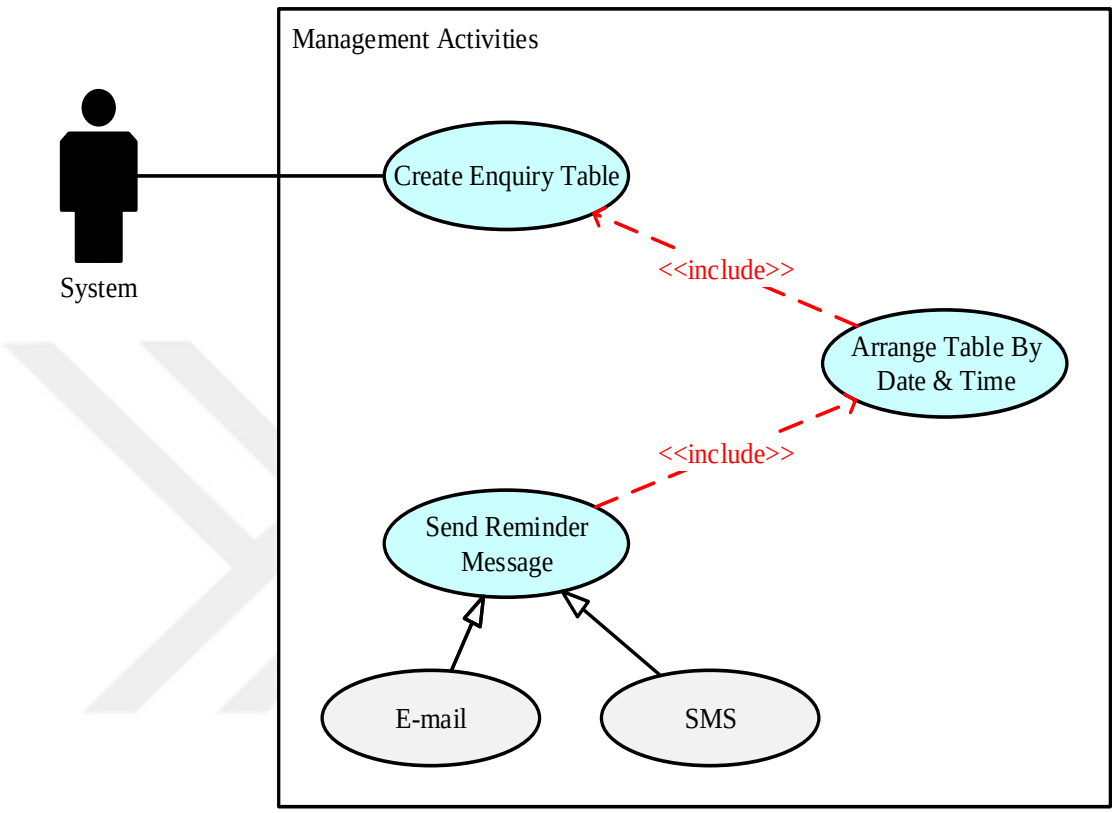

Figure 4.20 Use Case Diagram of Proposed System in Monitoring Layer

4.3.7. Summary of Monitoring Layer

According on the recommendation of developers, table 4.3 shows the summary of the monitoring layer. This table will support the developer to understand this layer in the first sight.

Therefore, this table will present a summary of this layer according to its main activities, functionalities, and the responsibility of each functionality.

Table 4.3 Summary of Monitoring Layer

Scene	Summary	Functionalities	Responsibilities
Monitoring health status of DS	Monitor health status contributed to support DS by providing proactive health services, by detect an emergency health condition in real time. The proposed system suggests using medical sensors as wearable devices to capture vital signals.	Create monitoring session	System
		Set proposed sensor	ARNP nurse
		Capture vital signals	System
		Automatic decision of health status	System
		Detect abnormal condition	System
		Approve abnormal condition	Doctor
		Create paramedic session	System
		Calculate shortest path	System
		Arrived to DS	Driver
		First aid	CAN nurse
		Bring DS to hospital	CAN + Driver
Management medical reviews of DS	Manage medical reviews contributes to remind the responsible people about the date and time of the next appointment by sending SMS or e-mail messages.	Create enquiry table	System
		Arrange enquiry table by date and time	System
		Send reminder messages	System

4.4 Scenario of Evaluation and Development Layer

The aim of this layer is to improve the performance of the proposed system.

4.4.1. Objectives of Evaluation and Development Layer

1) Monitoring the performance of proposed system.
2) Monitoring the future needs of DS.

4.4.2. The Flow Chart of Main Activities of Evaluation and Development Layer

Figure 4.21 shows the flow chart of the main activities of this layer, which will contribute to determine its requirements, participants and activities-in-detail.

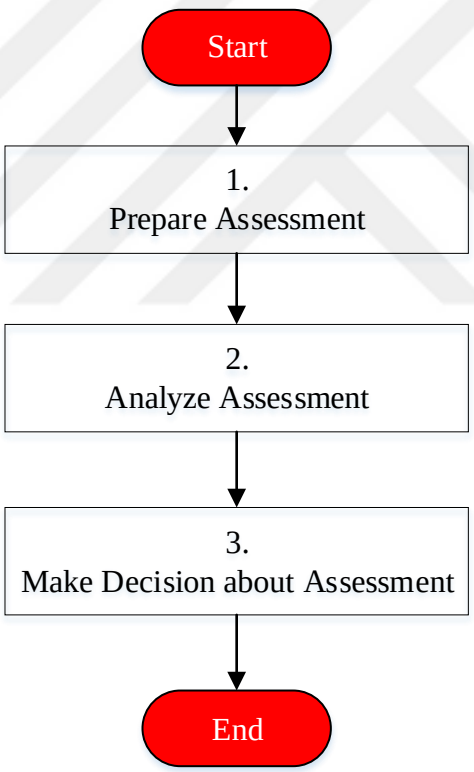

Figure 4.21 Main Activities of Evaluation and Development Layer

4.4.3. Requirements of Evaluation and Development Layer

According to the main activities of evaluation and development layer (figure 4.21), the technical' requirements that will contribute to this layer are follows:

1) PCs with all requirements and communication devices.
2) Special software with effective UI and Servers. In addition, this software must contain the followings:

    i. Dashboard platform that is integrated with the proposed software and consist of parameters for evaluating results like the amount of time it is being used, errors in all parts, positive and negative feedbacks, etc.
    ii. Statistical procedures integrated with proposed software.

4.4.4. Participants of Evaluation and Development Layer

All the previously mentioned people including the administrators are part of this layer.

4.4.5. Activities-in-Detail of Evaluation and Development Layer

The main idea of this layer is using a dashboard platform to monitor the status of DSIS. Therefore, activities-in-detail of this layer will described, and figure 4.22 below shows the flow chart of these activities.

a) Preparation of the assessment which is the responsibility of the administrator as follows:

    1) Prepare assessment plan that aims to satisfy the objectives of this layer, and prepare some assessment forms according to it, and the administrator is responsibility of it.
    2) Choose the necessary statistical functions for each assessment form.
    3) Sharing the assessment form with all participants.

b) Analyze of the assessment forms which are responsible for DSIS as follows:

    1) Collect feedbacks of assessment forms.
    2) Apply the statistical functions to analyze the feedbacks.

c) Make decision about assessments, whose responsibility belongs to DSIS as follows:

1) Check if the results are on the range, and send them for visualization on a dashboard.
2) If the results are out of range, send an alarm to the administrator.

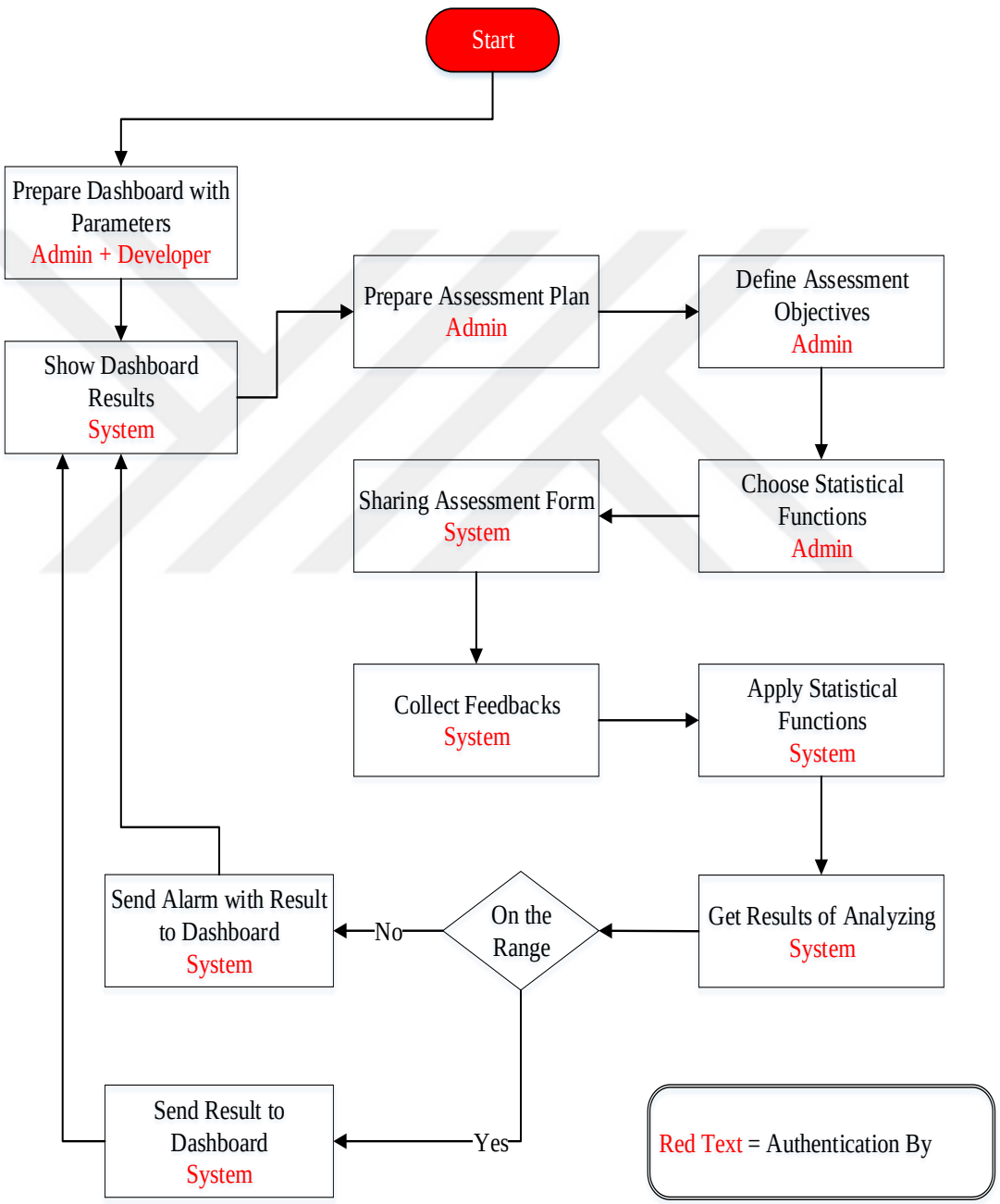

Figure 4.22 Flow Chart of Activity-in-Detail of Evaluation and Development Layer

4.4.6. Use Case Diagram of Evaluation and Development Layer

The use case diagrams of this layer was suggested to show the roles of all participants in this layer (figure 4.23). This diagram will depend on the main activities of this layer (figure 4.21).

According to the recommendation of the developers, the use case diagram for all participants is enough for the activities of this layer and it is described follows:

1) The developer is responsible for establishing a dashboard platform and integrate it with the proposed software.
2) The DSIS is responsible to present the results of all parameters on the dashboard.
3) The administrator is responsible for preparing assessments to evaluate the DSIS.
4) The proposed system is responsible of distribute assessments forms to all participants.
5) All participants associate will present their feedbacks.
6) The proposed system is responsible for analyzing results of all feedbacks automatically (by using some statistical functions).
7) The proposed system is responsible for making decision about the assessments of analysis and send alarm to be shown on the dashboard.

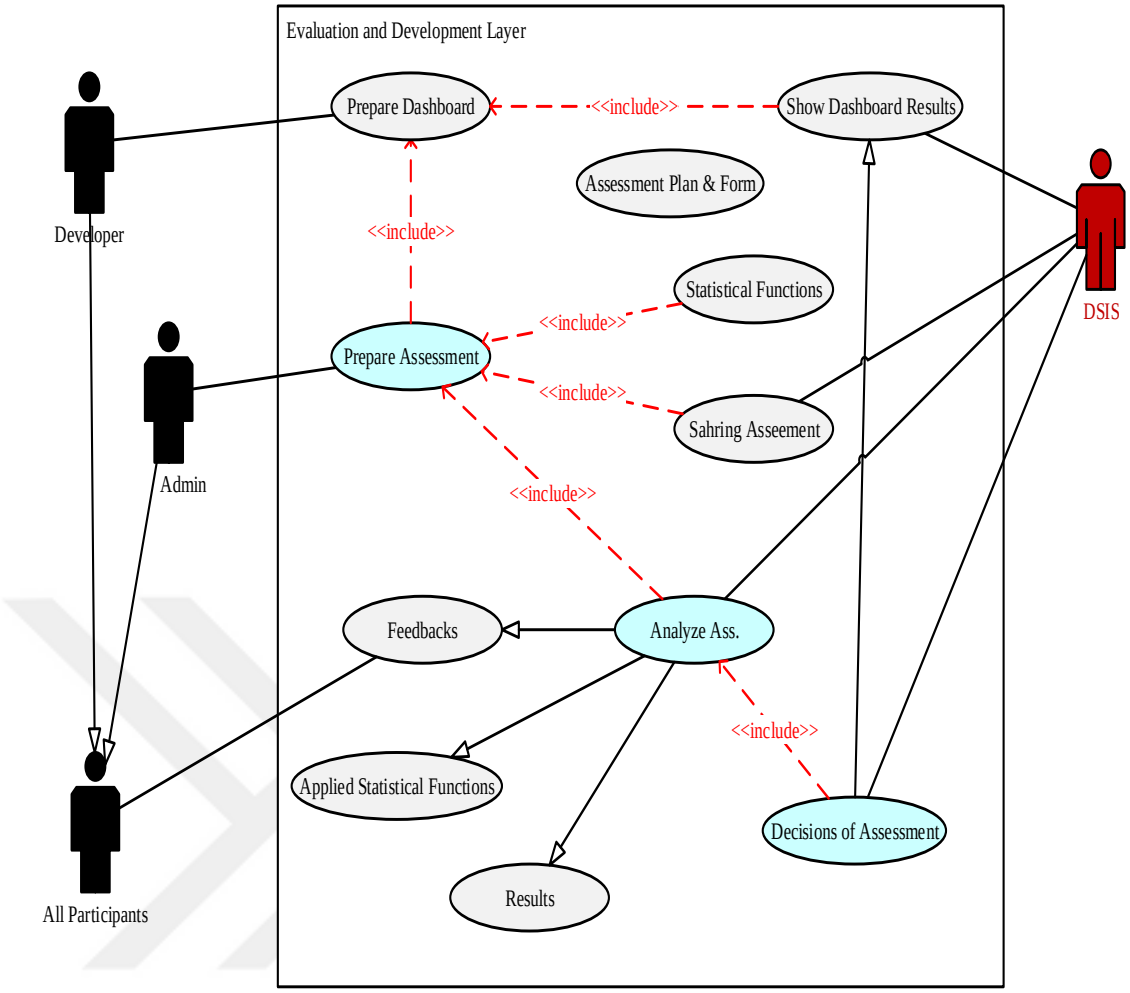

Figure 4.23 Use Case Diagram of Participants in Evaluation and Development Layer

4.4.7. Summary of Evaluation and Development Layer

According on the recommendations of the developers, table 4.4 shows the summary of monitoring layer. This table will support the developer to understand this layer in the first sight.

Therefore, this table will present a summary of this layer according to its main activities, functionalities of each main activities, and the responsibility of each functionality.

Table 4.4 Summary of Evaluation and Development Layer and required Functionalities

Scene	Summary	Functionalities	Responsibilities
Prepare Assessment	Prepare assessment contributes to preparing the form will be used to collect feedbacks and will be important in evaluating and developing the proposed system. It needs an established dashboard platform firstly.	Establish dashboard platform	Developer
		Showing assessment parameters in the dashboard	System
		Prepare assessment plan	Admin
		Prepare assessment objectives	Admin
		Prepare assessment forms	Admin
		Choose statistical functions	Admin
		Sharing assessment form	System
Analyze assess. form	This activity is responsible for collecting and analyzing results of the feedbacks.	Collect feedbacks	System
		Applied statistical functions	System
		Send results to analyze it	System
Make decisions	This activity is responsible to send an alarm with the value of the analysis to be shown on the dashboard.	If analysis is normal, send normal result to dashboard	System
		If analysis is abnormal, send results with alarm to the dashboard.	System

4.5. Scenarios of Supporting Layer

The aim of this layer is to support all participants by training them to use and maintain the system.

4.5.1. Objectives of Supporting Layer

1) Make an online maintenance for proposed system to ensure the reliability.
2) Support all participants by providing online workshops about the proposed system.

4.5.2. The Flow Chart of Main Activities of Supporting Layer

According of above objectives, figure 4.24 shows the flow chart about the main activities of this layer, which will contribute to determining the requirements, participants and activities-in-detail. The main activities are:

1) Maintenance of all equipment of proposed system.
2) Establish online workshops for all participants.
3) Prepare reports about maintenance and training activities.

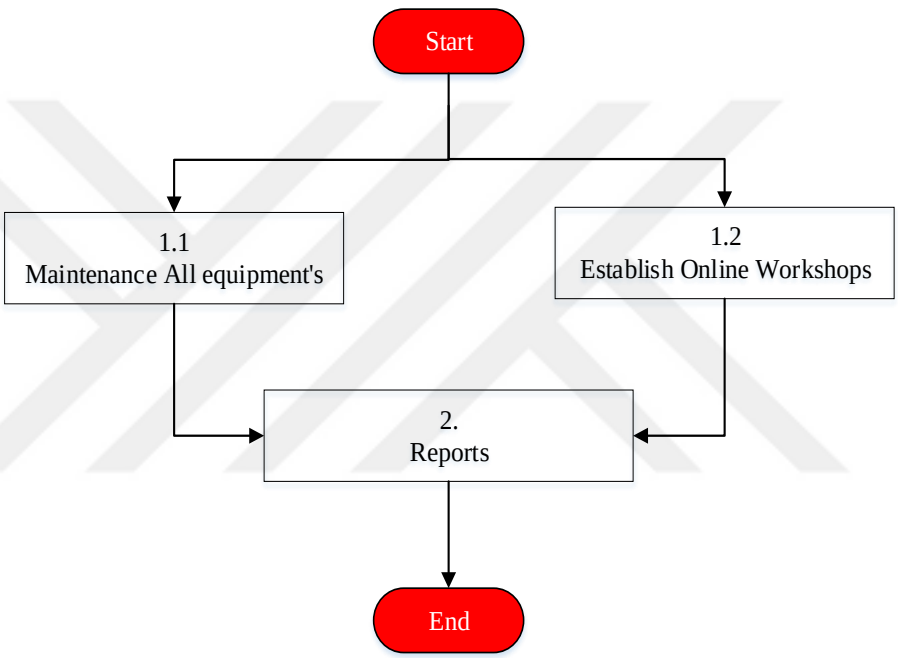

Figure 4.24 Main Activities of Supporting Layer

4.5.3. Requirements of Supporting Layer

According to the main activities of supporting layer (figure 4.24), the technical' requirements that will contribute to it are as follows:

1) PC with all requirements and communication devices.
2) Special software with effective UI and Servers. In addition, this software contains a dashboard platform integrated with proposed software, which consist of:

i. Alarms about maintenance.
ii. Parameters about training.

4.5.4. Participants of Supporting Layer

All above-mentioned participants, including administrators and technicians are part of this layer.

4.5.5. Activities-in-Detail of Supporting Layer

In the following, activities-in-details of supporting layer are giving in details.

a) Maintaining all equipment: the system is responsible to discover and predict defects before they occurs. The technicians are responsible to recover or change the problematic equipment, so the proposed framework suggests two approaches for maintenance, as follows:

   i. The run-to-failure approach: For any equipment that is not essential for operation (like printers, fax machines, scanner PC, card reader etc.). Their replacement is recommended in the real time by providing the spare parts before breakdown. The activities are:

      1) Check maintenance time
      2) Replace or recover the equipment.
      3) Update maintenance time.

   ii. The predictive approach: it recommends using a Computerized Maintenance Management System (CMMS) approach to maintain equipment used for essential operations such as sensors, communications equipment, database equipment, etc. This approach makes a decision about equipment according the instruction provided and uses the expert commendation. Moreover, the constant analysis and real time results can predict the replacement or recovery of the equipment before its damage. Figure 4.25 below, shows the flow chart of predictive approach to maintain the proposed system.

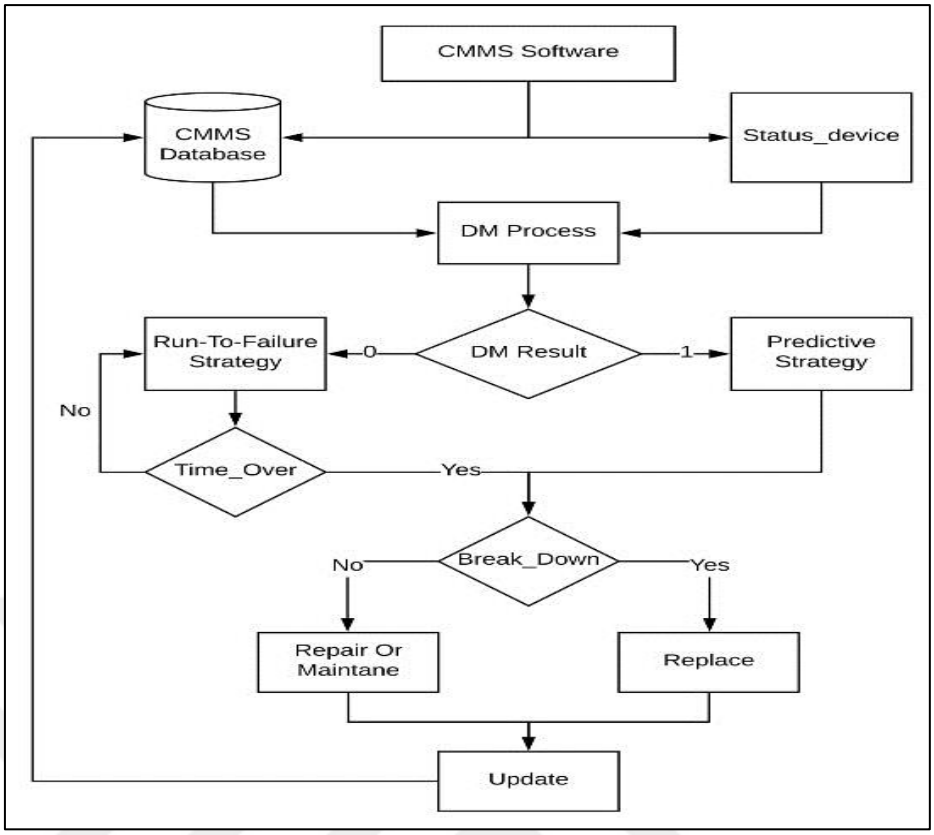

Figure 4.25 Predictive Approach to Maintain DSIS

b) Establishing online workshops for supporting participants to increase their skills. These activities are as follows:

1. Determine the courses needed based on evaluations.
2. Make planning of the course.
3. Define course objectives.
4. Define participants.
5. Implement the courses online.
6. Evaluate courses
7. Save results

Figure 4.26 below shows the flow chart of activities of supporting layer.

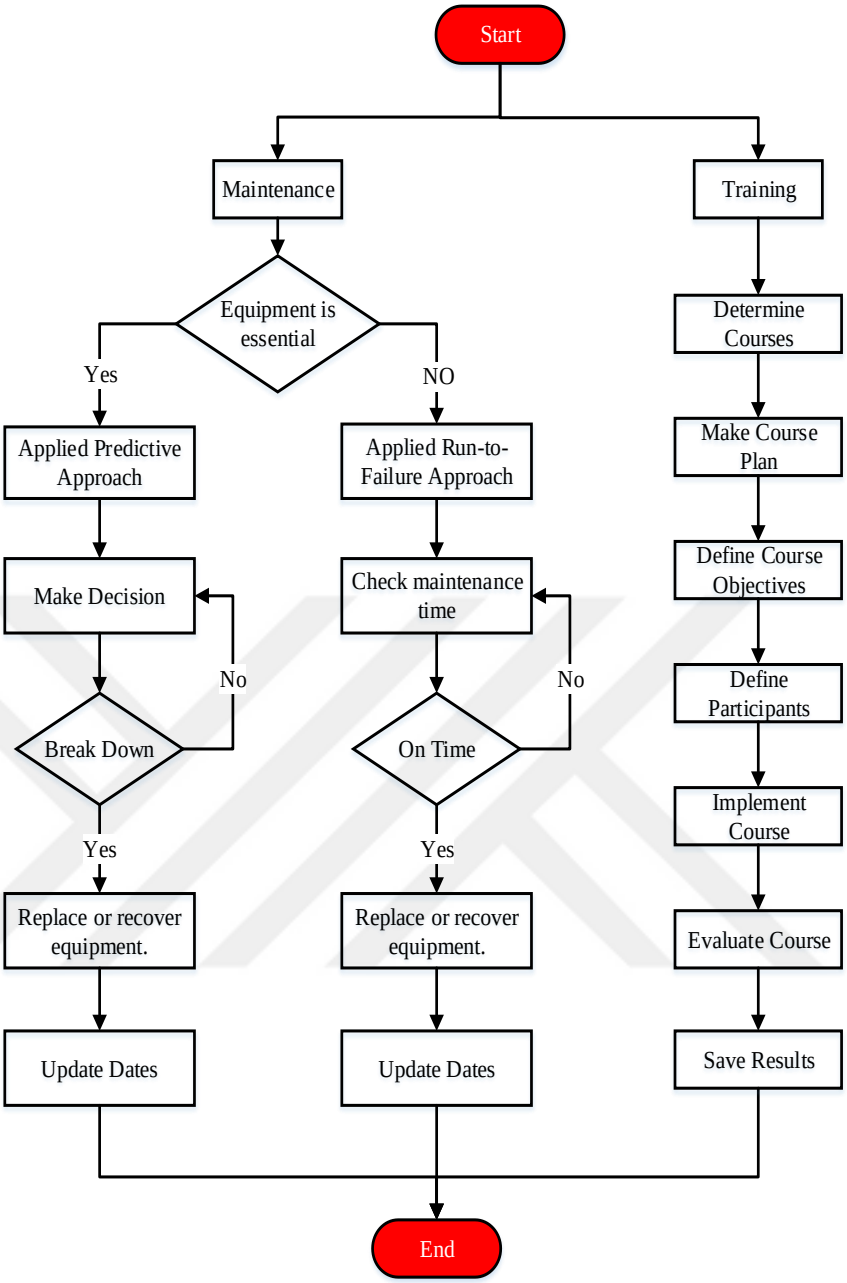

Figure 4.26 Flow Chart of Activity-in-Detail of Supporting Layer

4.5.6. Use Case Diagram of Supporting Layer

Figure 4.27 below shows the use case diagram for the role of proposed system and technician involved in its maintenance as and described below:

1) The proposed system is responsible for maintenance activities in general (except recover or change equipment), including the followings:

i. Determine maintenance approach.
ii. Make a decision about the time of maintenance.
iii. Update all results.

2) The technician is responsible of recover or replace the equipment according to the decisions by the proposed system.
3) The use case diagrams shows the role of investment on IT to keep the maintenance.

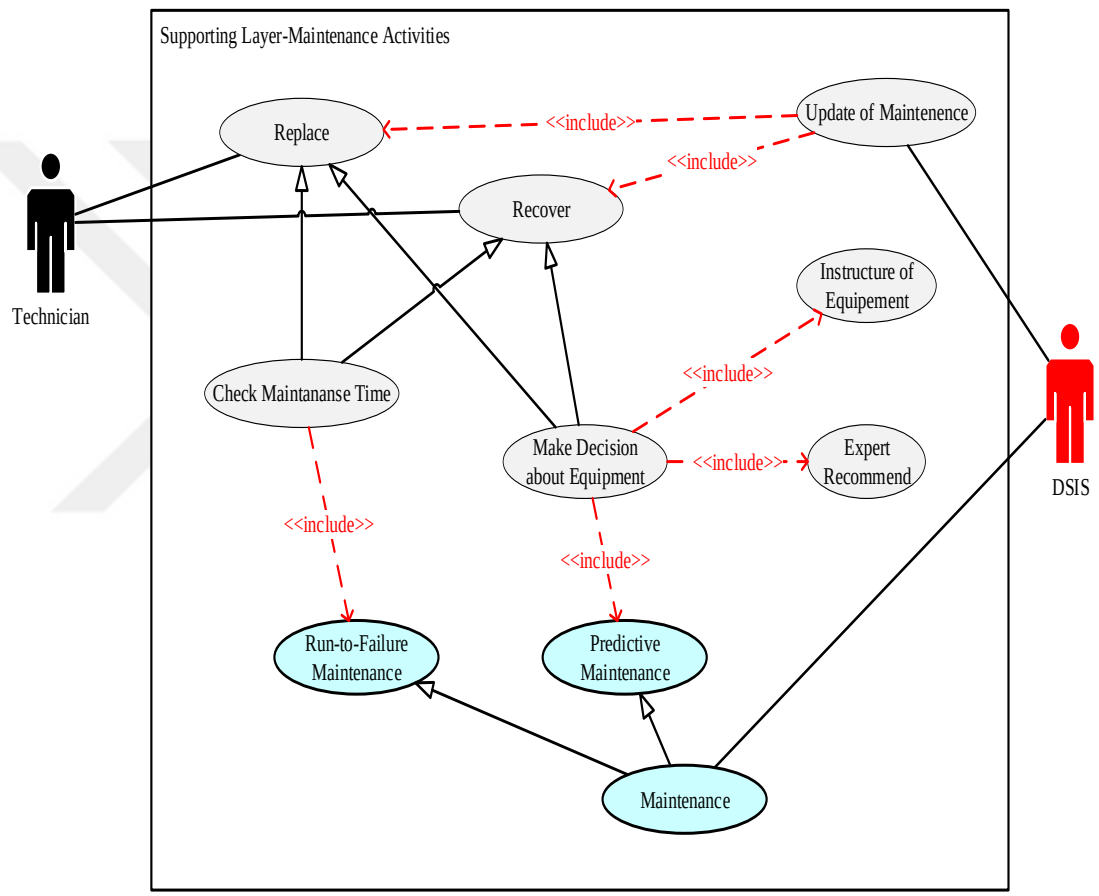

Figure 4.27 Use Case Diagram of DSIS and Technician in Maintenance Activities

Figure 4.28 below shows the use case diagram of the role of all participants in training activities that described as follows:

1) The proposed system is responsible for defining participants, implement and evaluate the identified course. It has to save all the results as well.

2) The admin is responsible to identify, plan and set the course's objectives.

3) All participants, including the admin take part in implementing the identified course.

4) The use case diagrams shows the role of investment on IT to provide training online.

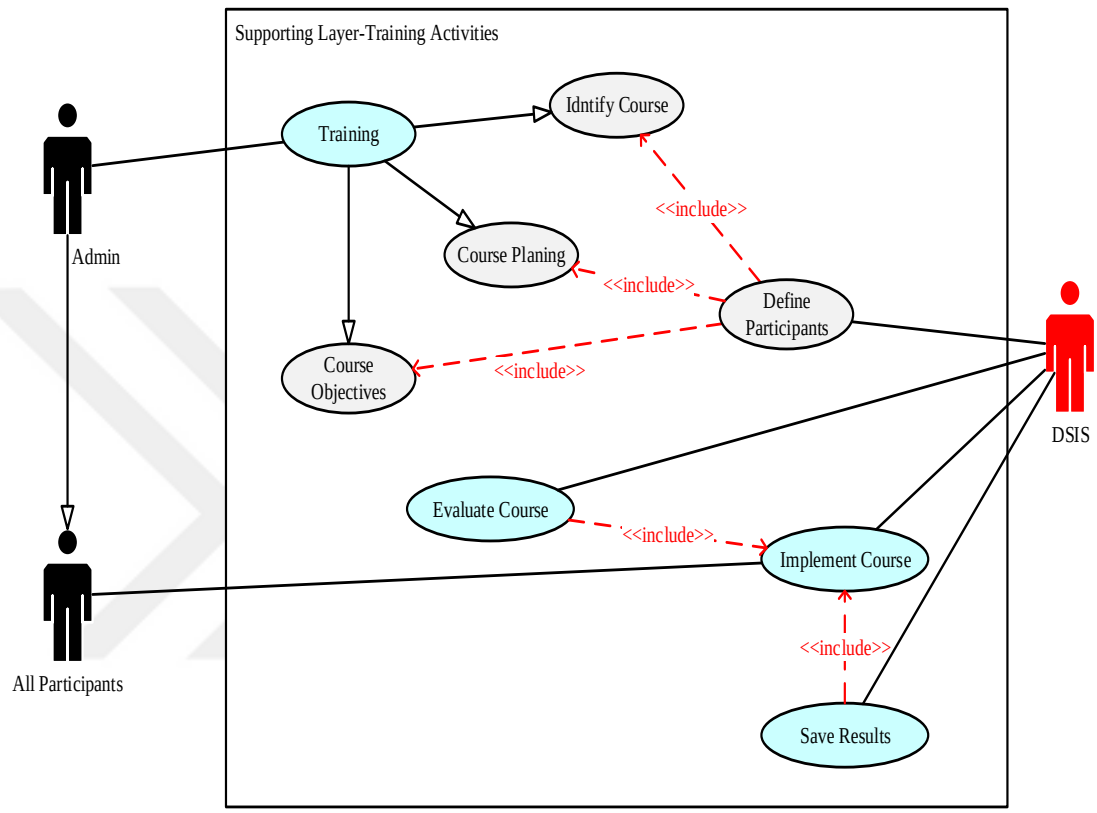

Figure 4.28 Use Case Diagram of All Participants in Training Activities

4.5.7. Summary of Supporting Layer

According to the recommendation of developers, table 4.5 shows the summary of supporting layer. This table will support the developer to understand this layer in the first sight.

Therefore, this table will present a summary of this layer according to its main activities, functionalities of each main activities, and the responsibility of each functionality.

Table 4.5 Summary of Supporting Layer and Required Functionalities

Scene	Summary	Functionalities	Responsibilities
Maintenance all equipment	This activity is responsible for maintaining all equipment.	**Run-to-Failure approach** a. Check maintenance time b. Replace or recover equipment	System Technician
		Predictive approach a. Make decision of predictive maintenance b. Replace or recover equipment	System Technician
		Update maintenance database	System
Establish online workshops	This activity is responsible for supporting all participants to increase their skills.	Determine courses	Admin
		Make course plan	Admin
		Define course objectives	Admin
		Define participants	System
		Implement course online	System
		Evaluate course	System
		Save Results	System

4.6. Class Diagram

According the recommendations of the developers, three layers of DSIS were visualized by using class diagrams. These diagrams contribute to modeling DSIS classes, define its attributes, operations, and the relationships among all its objectives. This contribution will support the developers to build a system according to Object-oriented programming concepts. Figures 4.29 to 4.31 shows the modeling of DSIS by class diagrams.

4.6.1. Class Diagram of Preparatory Layer

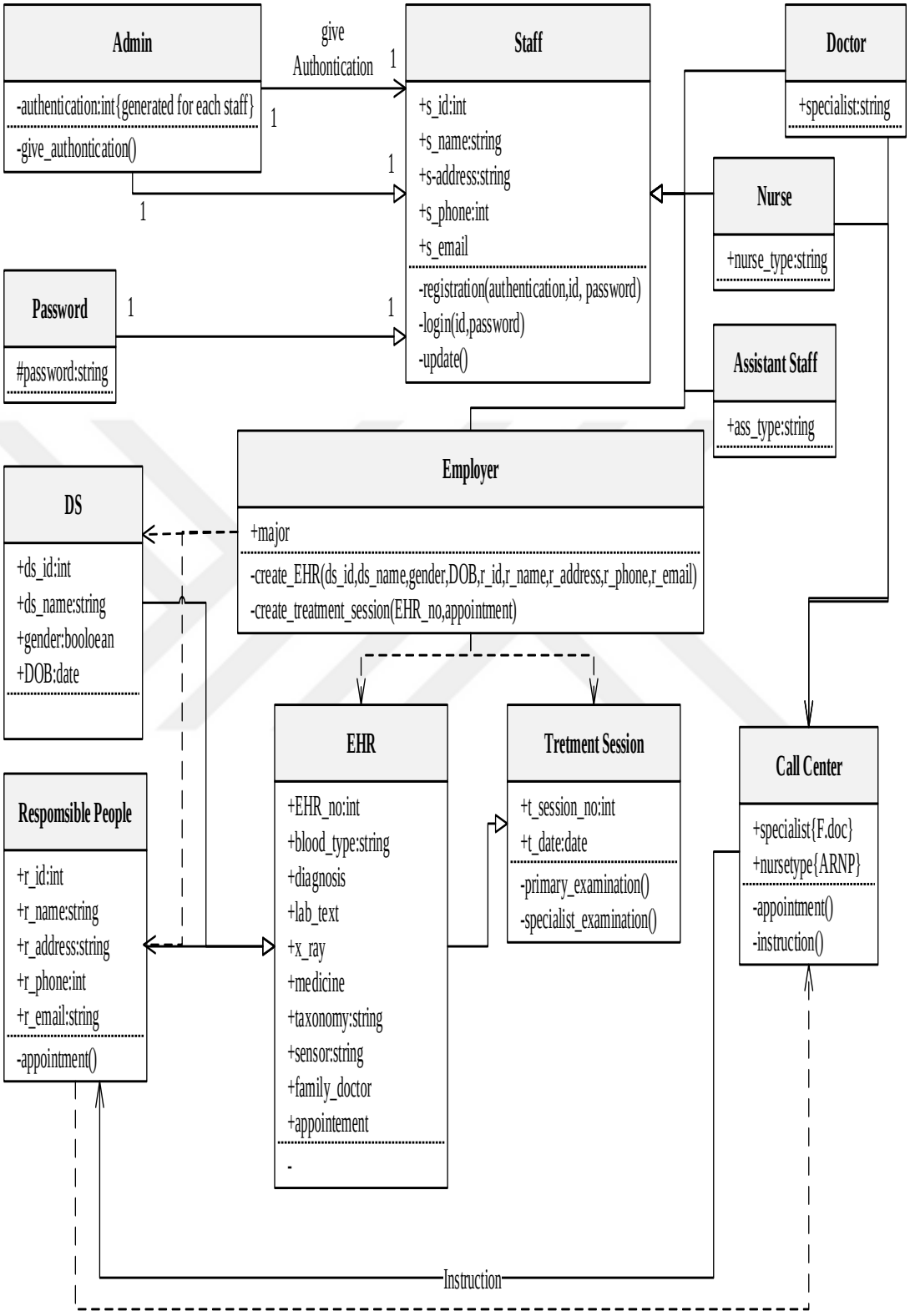

Figure 4.29 Class Diagram of Preparatory Layer

4.6.2. Class Diagram of Examination Layer

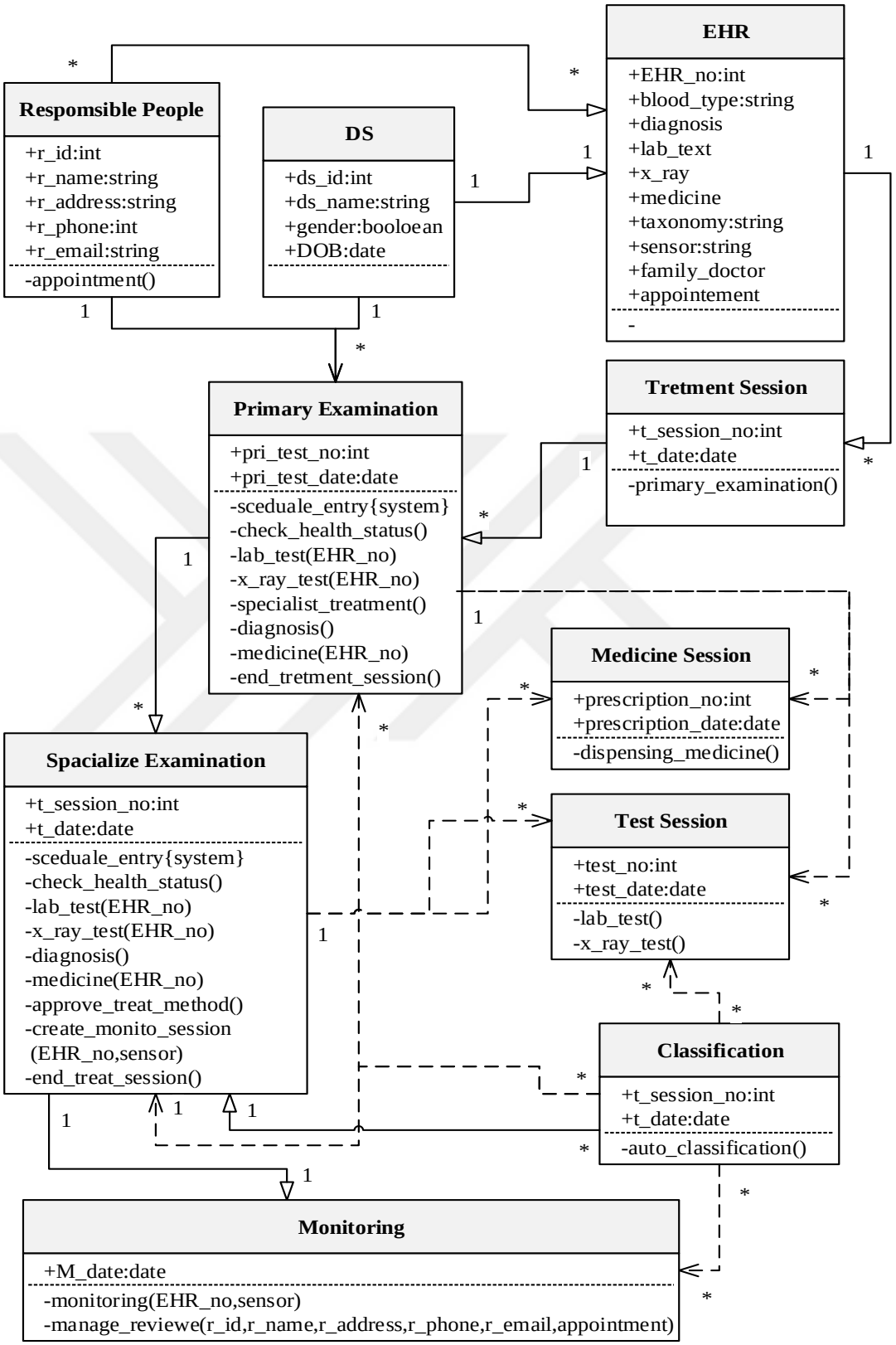

Figure 4.30 Class Diagram of Examination Layer

4.6.3. Class Diagram of Monitoring Layer

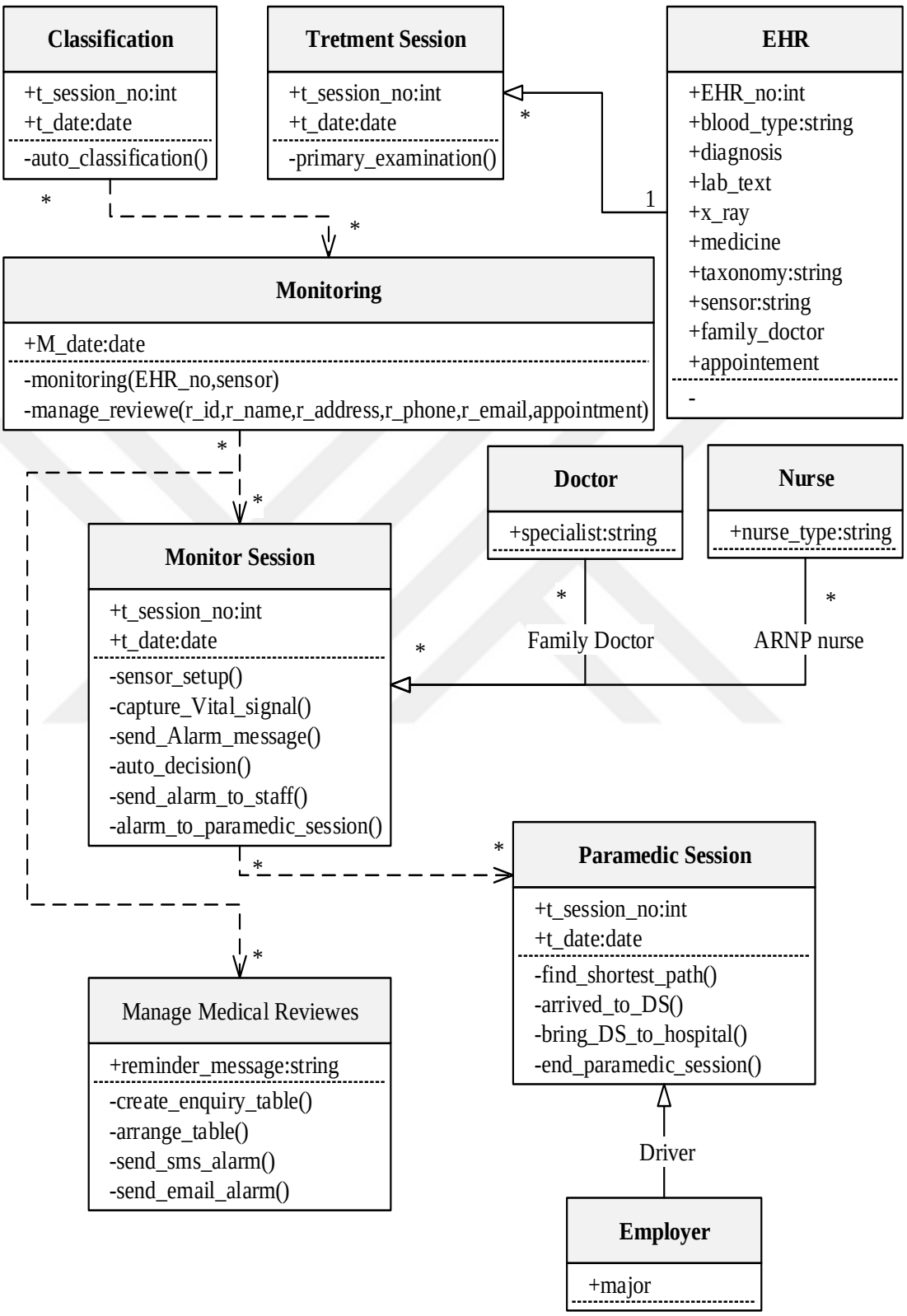

Figure 4.31 Class Diagram of Monitoring Layer

4.7. Thesis Contribution

After visualizing of DSIS, it was concluded that this framework will contributes in the following fields.

4.7.1 Enhance Health Status of Individuals with Down Syndrome

According the use case diagrams and class diagrams (sections 4.1.6, 4.2.6, 4.3.6, 4.4.6, 4.5.6, and 4.6) It can be concluded that this framework will definitely help to design a DSIS to enhance the health status. This system will used to monitor the abnormal vital signals, which indicate the possibility of diseases and manage the current and future medical reviews of them (according to the taxonomy of providing healthcare services in section 3.5.2).

Therefore, when the new system is compared with the current one systems, we can conclude that the current system can monitor health status, but it cannot manage the future medical reviews for individuals.

4.7.2 Create a Hybrid Health System

According the use case diagrams and class diagrams (sections 4.1.6, 4.2.6, 4.3.6, 4.4.6, 4.5.6, and 4.6). It can conclude that DSIS will enhance the provision of healthcare services for individuals with DS through their responsible people (parents or any responsible who cares them), because the responsible people are considered as assistants for them to receive and transfer data related to their DS children.

Therefore, when the new system is compared with the current one, it can conclude that the current system can only deal with the end user and no other user can share on the session treatment of other user.

4.7.3 Become an Educational Guide for Developers

According the outcomes of Chapter 3 (investigation section), and Chapter 4 (conceptual design). It have provided proof that this framework will serve as an educational guide for developers to build monitoring systems for DS, increase IT investment in this system, and build a hybrid system with the participation of the responsible people within it.

CHAPTER 5

FINDING AND CONCLUSION

As presented this study is about the possibility to set a framework for designing a new system called Down Syndrome Information System (DSIS) was study to ensure implement it by the developers. It means this thesis will be a guide for the developer to build this system and other that similar of it. The DSIS will be using to enhance health status of individuals with DS, by using medical sensors to monitor health status of DS' patients. Therefore, all Chapters of this thesis will try to answer thesis questions that mentioned in section 1.4.

Therefore, this Chapter aims to present the finding of this thesis, and the conclusion section will try to answer about these questions. In addition, the limitation and future studies will presented in this Chapter.

5.1. Findings

Findings that appears within this thesis were not limited to research questions, it consist some issues that will be used in the future studies. Therefore, finding that related of the main purpose of this thesis are as follows:

1. **Choose a framework as a main tool of implement DSIS.**

   According to the thesis motivation (section 3.1), this thesis was succeeded to choose a framework as a tool to ensure implement DSIS. This success was proved according of the related works that conducted in section 2.6, and the discussion of it in section 2.7. This framework will be contributes to ensure implement DSIS by using the first three steps of SDLC approach (investigation, analysis and design) as shown in figure 2.4 above.

2. The impact of information technology in DS' life

The related works in section 2.6 and discussion in section 2.7 proved that the impact of IT in the life of individuals with DS, nevertheless it still delayed in health sector.

Therefore, this thesis aims to invest in IT in health sector of DS' patients to enhance provide healthcare services for them.

3. Health status of individuals with Down syndrome

The investigation step in chapter 3 was succeed to assess the health status of individuals with DS, and it concluded that they have bad health status and it range from simple to severe due there are many complex health problems and lack of supporting especially in their health sector. In addition, it succeed to determine the most common health problems that faced DS' patients. This step was succeed according the following steps.

a) Succeed to identified the hypotheses about the health status of individuals with DS according the first and second steps of investigation (sections 3.1.1, 3.1.2, 3.1.4/A and 3.2), and concluded that the health problems and lack of support are independent variables that affect on the health status of individuals with DS.
b) Succeed to make an experimentation about the current health status of individuals of DS according the questionnaire that distributed on some Arabic countries (included Iraq) and get 151' feedbacks about it, as shown in section 3.3.1.
c) Succeed to test the above hypotheses by using a SPSS software to analyze the feedbacks of questionnaire as shown in section 3.4.
d) Succeed to assess the health status that mentioned above according the discussion and conclusion in section 3.5. It concluded that the independent variable is effective factor of the health status of individuals with DS.

4. Identified how DSIS works

This thesis was succeed to identify how the DSIS works, which will contribute to set a framework of DSIS. Therefore, this step was conducted according the following:

a) The DSIS will works to monitoring health status of individuals with DS by using a medical sensor. This monitoring based on the study of the most common health problems that faced DS' patients and the capability to use medical sensors to capture the vital signals that related of it, such as heart diseases (sections 3.1.1, 3.1.3). In addition, this thesis succeed to study the feasibilities of invest IT in healthcare services such as using a WSN to transfer data electronically (section 3.1.3 and 3.1.4/B).
b) The DSIS will works to management the medical reviews of individuals with DS by sending an alarm messages. This management based on the taxonomy of providing healthcare services that was conducted in section 3.5.2-table 3.11 above.
c) The DSIS will be a healthcare system to providing healthcare services, which contain the following departments (figure 3.20):

    i. A patient' reception department to create an EHR for them, manage the appointment of treatment, call center to support them and create a treatment session for patient' entry (section 4.1).
    ii. Department of primary and specialist treatments that provide healthcare services of them (sections 4.2 and 4.3).
    iii. Monitoring department to tracking the change of health status of individuals with DS (section 4.3).
    iv. departments of evaluation and supporting to ensure continuous work of DSIS, by make an online maintenance of the system, continuous developing it by continuous assessment all issues

of it, and make an online workshops to increase skills of all participants (sections 4.4 and 4.5).

5. Ensure implement DSIS

This is the important finding to satisfy the main question of this thesis, it consist the following:

a) According the finding 1, the framework is the effective tool to ensure implement any system.
b) This thesis was succeed to illustrate how system work, which be an important role to set a framework this system (finding 4).
c) This thesis was succeed to set and describe the conceptual design of DSIS, which was contributed to identify requirement, participants and activities of DSIS (Chapter 4).
d) This thesis was succeed to visualize the DSIS in view of users by using Use Case diagrams (sections 4.X.6, when X=1..5).
e) This thesis was succeed to modeling the DSIS by using class diagrams of three layers of it (section 4.6).

6. Interviews with experimental and academic experts.

In addition the questionnaire form, this thesis succeeded to conduct interviews with the experimental and academic experts to collect their skills to develop any system (section 3.3.2). The results of these interviews have been benefit in this thesis based on their recommendations to design a software system (section 3.4.2). The most important notes are focus on the end user needs beneficiaries of the proposed system through investigation that leads to define end user problems, as well as to define the requirement of proposed system. in addition, use diagrams to represent the activities as blocks and its connections, and they recommend to visualize the proposed system by using a UML diagrams to support the developer to understand how system work that lead to ensure implement

it. Therefore, these interviews was contributed to accept the hypotheses that defined.

7. Thesis contribution

In the following the thesis contribution:

a) This thesis will contribute to invest IT in health field for DS' patients by ensure design DSIS to monitor health status (section 4.7.1).
b) This framework will contribute to design a Hybrid System by integrate the responsible people of DS in the activities of healthcare sector (section 4.7.2).
c) This thesis will contributed to guide the developer to build this system or any other similar of it. Means it will be became an educational guide for developers (section 4.7.3).

Table 5.1 below, shows the compare between DSIS and current system that implement in some Arabic countries (included Iraq)

Table 5.1 Comparing Current System with DSIS

	Current System	DSIS
Invest IT in healthcare services	Yes	Yes
Special health system for DS	No	Yes
The end user who use the system	Patient	Responsible people
Monitoring health status by sensors	Yes	Yes
Manage medical reviews	No	Yes

5.2. Limitations

Limitations of this thesis are presenting as follows.

1. Limitation in information present in international journals and conferenced in related works section (section 2.6) and observation section (section 3.1).
2. This thesis is limited to DS since it was chosen as case study due to motivation that presented in section 1.3.
3. In Chapter 3, the SPSS software with Pearson correlation function was used, as it was enough to find the correlation among parameters of questionnaire form.
4. For system development approach, it used investigation, analysis (integrated with investigation) and design, which were seen as good enough to set the proposed framework (Chapters 3 and 4)
5. For questionnaire form, it distributed among three countries due of the difficulties of collecting more samples.
6. As mentioned in table 5.1, the main motivation for this thesis was the personal experiences of the author with his close persons to assess the current health status and used it to compare with the proposed system.
7. As mentioned in chapter 4, this thesis does not include a database of DSIS, but will leave it to be designed in a future study.

5.3. Future Studies

The importance of this thesis is to support the developer to design a new system for enhance providing healthcare services.

Therefore, in the following the more important study will need to prepare it in the future.

As presented, there are more steps more to finish the life cycle of development, which need to finish it in the future. These steps as follows:

1. Implementation this system.

2. Apply the implementation on the real sample to get feedbacks.
3. Test this implementation on the limited real sample to collect more feedbacks. Therefore, this thesis suggest using a test case template as shown in tables 5.1 and 5.2 below.

Project Name: DSIS

Test Case	
Test Case ID: DSIS_01	**Test Designed by:** <developer>
Test Priority (Low/Medium/High): Med	**Test Designed date:** <Developer test>
Module Name: Login system	**Test Executed by:** <XXX>
Test Title: Verify login with valid username and password	**Test Execution date:** <XXX>

Pre-conditions: User has valid username and password
Dependencies:

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Navigate to login page	User= example@XXX.com	User should be able to login	User is navigated to		
2	Provide valid username	Password: 1234		dashboard with successful		
3	Provide valid password			login		
4	Click on Login button					

Figure 5.1 Test Case Template to Test Valid Login

Project Name: DSIS

Test Case	
Test Case ID: DSIS_02	**Test Designed by:** <developer>
Test Priority (Low/Medium/High): Med	**Test Designed date:** <Developer test>
Module Name: Wrong to login system	**Test Executed by:** <XXX>
Test Title: Verify the system to detect the wrong to login	**Test Execution date:** <XXX>

Pre-conditions: User has invalid username and password
Dependencies:

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Navigate to login page	User= example@YYY.com	User should be unable to login	User is navigated to		
2	Provide invalid username	Password: 000		dashboard with un successful		
3	Provide invalid password			No login		
4	Click on Login button					

Figure 5.2 Test Case Template to Test Invalid Login

4. This thesis used a DS as a kind of disability. Therefore, it will develop the system to cover more than disabilities, especially who needs a responsible people like Autism
5. The proposed framework towards on healthcare field. Therefore, it will extend it to cover more than fields like education or transportation, which leads to increase supporting them in more than fields in the life.
6. Describe and design the DBMS that used in DSIS.

5.4. Conclusion

As shown, setting a framework is based on two factors.

1. Ensure availability of successful parameters by planning and resources.
2. Ensure implement the proposed system.

Based on the results of this thesis, we can reach the following conclusions:

1. It is important to apply the scientific method to make any investigation. In addition, choosing UML diagrams to visualize the proposed system is essential to its success. Means, the methodology of this thesis was succeed to set a framework to design a monitoring system for DS patients.
2. Using SPSS statistical software makes possible the analysis of the data and obtaining results according to scientific approach, which proves succeeded to provide scientific techniques for success.
3. There was compatibility between hypotheses and results, which is a testimony of the success in choosing DS and health scope as case studies.
4. Visualized the proposed system by using a use case and class diagrams to prove the proposed framework is implementable.
5. The proposed framework succeeded to embed responsible people within the proposed system, and make a hybrid system.
6. The IT proved its role to improve healthcare system by managing and controlling all patients successfully.

Therefore, when it comes to the main research question:

Can the proposed framework support the developer to design a Down syndrome information system?

Which in turn would lead to answer the following 4 others:

1. Can the proposed system satisfy end users?
2. Can the proposed system increase IT investment in the health care field?
3. Is the proposed system implementable by a developer?
4. What are the differences between the proposed system and the old system?

As mentioned before, Chapter two was succeeded to define the scope and purpose of this thesis. In addition, to choose a scientific method to set this framework, which contributed to define the methodology of this thesis.

According outcomes of Chapter 3, the investigation was prove that the DS patients have a bad health status due they face a big health problem and lack the supporting in health sector. In addition, this Chapter was prove that the framework will contributed to build a system to satisfy the end user's needs (enhance health status). All of these will leads to invest on IT in healthcare field by integrated medical sensors and network connections. Means, Chapter Three will confirm the first and second questions of this thesis.

According outcomes of Chapter 4, the conceptual design contributed to visualizing the proposed system by using a UML diagrams. In addition, it also succeeded in defining requirements and participants of the proposed system. This means that Chapter Four answered the third and fourth questions of this thesis.

Answering these four questions leads to answering the main question which is positive. Indeed, this this framework will be able to support the developers in building a DSIS and satisfy its objectives.

REFERENCES

[1] A. Mégarbané et al., "The 50th anniversary of the discovery of trisomy 21: the past, present, and future of research and treatment of Down syndrome," *Genetics in Medicine,* vol. 11, no, 9, pp. 611-616, 2009.

[2] G. Bassellier, B.H. Reich, and I. Benbasat, "Information technology competence of business managers: A definition and research model," *Journal of Management Information Systems,* vol. 17, no. 4, pp. 159-182, 2001.

[3] J.A. O'Brien, and G.M. Marakas, "Management information systems," McGraw-Hill Irwin, 2007.

[4] M. McGinnis, and E. Ostrom, "Social-ecological system framework: initial changes and continuing challenges," *Ecology and Society,* vol. 19, no. 2, 2014.

[5] M. Kazemi, M. Salehi, and M. Kheirollahi, "Down Syndrome: Current Status, Challenges and Future Perspectives," *International Journal of Molecular and Cellular Medicine*, vol. 5, no. 3, pp. 125-133, 2016.

[6] D. Kaplan, "The definition of disability: Perspective of the disability community," *J. Health Care L. & Pol'y 3,* p. 352, 1999.

[7] L. Matilde et al., "The definition of disability: what is in a name?," *The Lancet,* vol. 368, no. 9543, pp. 1219-1221, 2006.

[8] M. Malcolm, and L. Swartz, "Disability & international development: Towards inclusive global health," Springer Science & Business Media, 2009.

[9] Government of Western Australia, "Disability Access and Inclusion Plan 2016-2020," reports and publications, Department of Health, official web site: http://ww2.health.wa.gov.au/Reports-and-publications, 2016.

[10] D.M. Browder et al., "Research on reading instruction for individuals with significant cognitive disabilities," *Exceptional children*, vol. 72, no. 4, pp. 392-408, 2006.

[11] T.J. Gerschick, "Toward a theory of disability and gender," *Signs: Journal of women in culture and society*, vol. 25, no. 4, pp. 1263-1268, 2000.

[12] J.R. Korenberg et al., "Down syndrome phenotypes: the consequences of chromosomal imbalance," *Proceedings of the National Academy of Sciences*, vol. 91, no. 11, pp. 4997-5001, 1994.

[13] T. Heather, and G. Unwin. "Down Syndrome: An Introduction for Parents and Carers," *Journal of Intellectual Disability Research*, vol. 52, no. 1, pp.91-92, 2008.

[14] K. Hitoshi, and T. Tomiyama, "A framework for computer-aided conceptual design and its application to system architecting of mechatronics products," *Computer-Aided Design*, vol. 44, no. 10, pp. 931-946, 2012.

[15] E.D. Falkenberg, "A framework of information system concepts," *International Federation for Information Processing*, 1998.

[16] S. Stair, G. Reynolds, "Principles of information systems," Cengage Learning, 2013.

[17] R. Haux, "Health information systems–past, present, future," *International journal of medical informatics*, vol. 75, no. 3-4, pp. 268-281, 2006.

[18] D. Bracoo, and F. Labeau, "Electronic health record: what do you expect from them?," *Critical care medicine*, vol. 43, no. 6, pp. 1342-1344, 2015.

[19] D. Kalra, "Electronic health record standards," *Yearbook of medical informatics*, vol. 15, no. 1, pp. 136-144, 2006.

[20] V.T. Sarinho, A.O. Mota, and E.P. Silva, "Towards an e-Health Cloud Solution for Remote Regions at Bahia-Brazil," *Journal of medical systems*, vol. 42, no. 2, 2018.

[21] E. Becker-Barroso, "Strengthening connections between Down syndrome and AD," *Lancet Neurol*, vol. 12, 2013.

[22] The US National Institutes of Health, "The Down Syndrome Consortium Registry," official web site: https://dsconnect.nih.gov, (last visited date: 18/5/2017).

[23] J.A. Vergara, Y.M. Ramírez, and J.E. Camargo, "A pervasive and ubiquitous mobile health application for tracking people with disabilities," *10th Computing Colombian Conference (10CCC), IEEE*, pp. 206-213, 2015.

[24] B. Graf, R.S. King, C. Schiller, A. Roessner, "Development of an intelligent care cart and new supplies concepts for care homes and hospitals," *47st International Symposium on Robotics, Proceedings of VDE*, pp. 1-6, 2016.

[25] B.L. Schooley, S.S. Feldman, and N.S. Alnosayan, "Development of a Disability Employment Information System: An Information Systems Design Theory Approach," *44th Hawaii International Conference on System Sciences, IEEE*, pp. 1-10, 2011.

[26] P. Kruszka et al., "Down syndrome in diverse populations," *American Journal of Medical Genetics Part A*, vol. 173, no. 1, pp. 42-53, 2017.

[27] K. R. Cebula et al., "Emotion Recognition in Children with Down Syndrome: Influence of Emotion Label and Expression Intensity," *American Journal on Intellectual and Developmental Disabilities*, vol. 122, no. 2, pp. 138-155, 2017.

[28] L. Hippolyte, K. Barisnikov and M. Van der Linden, "Face processing and facial emotion recognition in adults with Down syndrome," *American Journal on Mental Retardation*, vol. 113, no. 4, pp. 292-306 2008.

[29] Q. Zhao et al., "Hierarchical constrained local model using ICA and its application to Down syndrome detection," *International Conference on Medical Image Computing and Computer-Assisted Intervention, Springer Berlin Heidelberg*, pp. 222-229, 2013.

[30] W. Zhao et al., "Face recognition: A literature survey," *ACM computing surveys (CSUR)*, vol. 35, no. 4, pp. 399-458, 2003.

[31] L. Wang et al., "Smartphone-based wound assessment system for patients with diabetes," *IEEE Transactions on Biomedical Engineering*, vol. 62, no. 2, pp. 477-488, 2014.

[32] K. Karthik, and K.M. Sowmyashree, "Smartphone-Based Wound Assessment System for Patients with Diabetes," *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, vol. 2, no. 3, 2017.

[33] M. Milošević, M.T. Shrove, and E. Jovanov, "Applications of smartphones for ubiquitous health monitoring and wellbeing management," *JITA-Journal of Information Technology and Aplications*, vol. 1, 2011.

[34] C.G. Scully et al., "Physiological parameter monitoring from optical recordings with a mobile phone," *IEEE Transactions on Biomedical Engineering*, vol. 59, no. 2, pp. 303-306, 2012.

[35] G.J. Mathew et al., "Development and validation of a smartphone heart rate acquisition application for health promotion and wellness telehealth applications," *International journal of telemedicine and applications*, 2012.

[36] Barnett, Julie, et al. "myPace: an integrative health platform for supporting weight loss and maintenance behaviors," *IEEE journal of biomedical and health informatics*, vol. 19, no. 1, pp. 109-116, 2015.

[37] A. Giovanni et al., "A survey on ambient intelligence in healthcare," *Proceedings of the IEEE*, vol. 101, no. 12, pp. 2470-2494, 2013.

[38] R. Silvia and A. Braun, "Money Handling Training-Applications for Persons with Down Syndrome," *12th International Conference on Intelligent Environments (IE), IEEE*, pp. 214-217, 2016.

[39] S.S. Dhyaa, and F.N. Ali, "Electronic-Health in Iraq," *International Journal of Advanced Research*, vol. 4, no. 8, pp. 295-305, 2016.

[40] S.S. Dhyaa, and F.N. Ali, "Iraqi Electronic Government in Health Care," *International Conference on Computer and Applications*, 2017.

[41] M.A. Khanapi and F.N. Ali, "Electronic Health Records Challenges and Barriers in Iraq," *Computer Engineering and Intelligent Systems*, vol. 7, no. 6, 2016.

[42] M.A. Khanapi M. A. and F.N. Ali, "Comparative study of electronic health records of Iraq and developed countries," *Journal of Software Engineering & Intelligent System*, vol. 2, no. 2, 2017.

[43] H.R. Hassibian, "Electronic health records acceptance and implementation in developing countries: Challenges and barriers," *Razavi International Journal of Medicine*, vol. 1, no. 1, pp. 6-11, 2013.

[44] M.K.A Ghani, M.M. Jaber, "The Effect of Patient Privacy on Telemedicine Implementation in Developing Countries: Iraq Case Study," *Research Journal of Applied Sciences, Engineering and Technology*, vol. 11, no. 11, pp.1233-1237, 2015.

[45] L. Pita et al, "Designing a quality Health Information System: Case study analysis in Papua New Guinea," *2015 Fifteenth International Conference on Advances in ICT for Emerging Regions (ICTer), IEEE*, p. 270, 2015.

[46] D.M. Kadijevich, G. Odovic, and D. Maslikovic, "Using ICT and Quality of Life: Comparing Persons with and Without Disabilities," *International Conference on Computers Helping People with Special Needs, Springer, Cham*, pp. 129-133, 2016.

[47] National Academies of Sciences, Engineering, and Medicine, "Improving diagnosis in health care," National Academies Press, 2016.

[48] T. Shimizu, T. Nemoto, and Y. Tokuda, "Effectiveness of a clinical knowledge support system for reducing diagnostic errors in outpatient care in Japan: A retrospective study," *International journal of medical informatics*, vol. 109, pp. 1-4, 2018.

[49] K.M. Wang, and L. Hui, "Smart environment effectiveness analysis of a pursuit and evasion scenario," *Journal of Ambient Intelligence and Humanized Computing*, vol. 10, no. 2, pp. 629-639, 2018.

[50] M. Amiribesheli, A. Benmansour, and A. Bouchachia, "A review of smart homes in healthcare," *Journal of Ambient Intelligence and Humanized Computing*, vol. 6, no. 4, pp. 495-517, 2015.

[51] B.R. Carter, "Remote patient monitoring system," *U.S. Patent Application*, no. 15/393, 650, July 2017.

[52] M. Morris, S.S. Intille, and J.S. Beaudin, "Embedded assessment: overcoming barriers to early detection with pervasive computing," *International Conference on Pervasive Computing, Springer, Berlin, Heidelberg*, pp. 333-346, 2005.

[53] S. Sebastian et al., "Remote patient monitoring system," *International Journal of Distributed and Parallel Systems*, vol. 3, no. 5, pp. 99, 2012.

[54] M. Delrobaei et al., "Towards remote monitoring of Parkinson's disease tremor using wearable motion capture systems," *Journal of the neurological sciences*, vol. 384, pp. 38-45, 2018

[55] D.M. West, "Improving health care through mobile medical devices and sensors," *Brookings Institution Policy Report*, vol. 10, pp. 1-13, 2013.

[56] A.D. Jurik, and A.C. Weaver, "Remote medical monitoring," *Computer*, vol. 41, no. 4, pp. 96-99, 2008.

[57] M. Gaynor, J. Waterman, "Design framework for sensors and RFID tags with healthcare applications," *Health Policy and Technology*, vol. 5, no. 4, pp. 357-369, 2016

[58] A. Ravitz, M.C. Grant, and C. Grant. "The Future of Healthcare through a Systems Approach," *13th Annual Conference on System of Systems Engineering (SoSE), IEEE*, pp. 527-534, 2018.

[59] M. McMurtrey, "A case study of the application of the systems development life cycle (sdlc) in 21st century health care: Something old, something new?," *Journal of the Southern Association for Information Systems*, vol. 1, no. 1, 2013.

[60] W. Chansanam, U. Detthamrong, "The Development of First Aid Mobile Application for Health Care Volunteers in Thailand," *Journal of Information Science*, vol. 36, no. 4, pp. 18-38, 2018.

[61] P. Keen, S. Qureshi, "Organizational transformation through business models: a framework for business model design," *39th Annual Hawaii International Conference on System Sciences (HICSS'06)*, vol. 8, 2006.

[62] S. Guetat, and S.B.D. Dakhli, "The Information City: A Framework For Information Systems Governance," *Mediterranean Conference on Information Systems (MCIS)*, pp. 1377-1388, 2009.

[63] C.J. Bacon, and B. Fitzgerald, "A systemic framework for the field of information systems," *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*, vol. 32, no. 2, pp. 46-67, 2001.

[64] A.A. Sulaiman, Y. Sulaeman, and B. Minasny. "A Framework for the Development of Wetland for Agricultural Use in Indonesia," *Resources*, vol. 8, no. 1, 2019.

[65] T. Diaz et al. "Framework and strategy for integrated monitoring and evaluation of child health programmes for responsive programming, accountability, and impact," *BMJ 362*, 2018.

[66] D. Riehle, "Framework. A Role Modeling Approach'," Diss. Ph. D. Thesis, Swiss Federal Institute of technology, Zurich, 2000.

[67] R.B. Pojasek, "A framework for business sustainability," *Environmental Quality Management*, vol. 17, no. 2, pp. 81-88, 2007.

[68] J. Price, "How to write a computer manual: A handbook of software documentation," Benjamin-Cummings Publishing Co., Inc., 1984.

[69] I. Sommerville, "Software documentation," *Lancaster University, UK*, pp. 143-154, 2001.

[70] A. Röder, and B. Tibken, "A methodology for modeling inter-company supply chains and for evaluating a method of integrated product and process documentation," *European Journal of Operational Research*, vol. 169, no. 3, pp. 1010-1029, 2006.

[71] M.S.A. Mahmoud, "Improve of health care systems for smart hospitals based on uml and xml," *International Journal of Computer and Information Technology (IJCIT)*, vol. 2, no. 3, pp. 484-491, 2013.

[72] F.R.M. Leijten et al., "The SELFIE framework for integrated care for multi-morbidity: development and description," *Health Policy*, vol. 122, no. 1, pp. 12-22, 2018.

[73] F.K. Thiong'o, "Framework for the Implementation of a Patient Electronic Referral System: Case Study of Nairobi Province," *JKUAT Annual Scientific Conference*, 2017.

[74] X. Kong et al. "Development of a conceptual framework for improving safety for pedestrians using smartphones while walking: challenges and research needs," *Procedia Manufacturing*, vol. 3, pp. 3636-3643, 2015.

[75] A. Moeed, "Science Investigation: Student Views about Learning, Motivation and Assessment," Springer, 2015.

[76] G. Dodig-Crnkovic, "Scientific methods in computer science," *Proceedings of the Conference for the Promotion of Research in IT at New Universities and at University Colleges in Sweden-Skövde-Suecia*, pp. 126-130, 2002.

[77] S.A. Kauffman, "Investigations," Oxford University Press, 2000.

[78] WO. Europe, "The European definition of general practice/family medicine," Barcelona: WONCA Europe, 2002.

[79] M.J. Park et al., "The health status of young adults in the United States," *Journal of Adolescent Health*, vol. 39, no. 3, pp. 305-317, 2006.

[80] M.J. Bull "Health supervision for children with Down syndrome," *American Academy of Pediatrics Clinical Report*, vol. 128, no. 2, pp. 393-406, 2011.

[81] M.J. Guralnick, "Early intervention approaches to enhance the peer-related social competence of young children with developmental delays: A historical perspective," *Infants and Young Children*, vol. 23, no. 2, pp. 73–83, 2010.

[82] M.J. Guralnick, "Why early intervention works: A systems perspective," *Infants and Young Children*, vol. 24, no. 1, pp. 6–28, 2011.

[83] J.H.Rimmer et al., "Improvements in physical fitness in adults with Down syndrome," *American Journal on Mental Retardation*, vol. 109, no. 2, pp. 165-174, 2004.

[84] K. Williams et al., "Disparities in Health Supervision for Children with Down Syndrome," *Clinical Pediatrics*, vol. 56, no. 14, pp. 1319-1327, 2017.

[85] M.J. Maclean et al., "Maltreatment risk among children with disabilities," *Pediatrics*, vol. 139, no. 4, 2017.

[86] W.S. Diana, "Cognitive Deficits," available web site: http://emedicine.medscape.com/article/917629-overview#a2, last update: Jan 20, 2016.

[87] D.S. Smith, "Health care management of adults with Down syndrome," *American family physician*, vol. 64, no. 6, pp. 1031-1044, 2001.

[88] B. Sacks, and A. Wood, "Hearing disorders in children with Down syndrome," *Down Syndrome News and Update*, vol. 3, no. 2, pp. 38-41, 2003.

[89] A. Hildmann, H. Hildmann, and A. Kessler, "Hearing disorders in children with Down's syndrome," *Laryngo-rhino-otologie*, vol. 81, no. 1, pp. 3-7, 2002.

[90] E. Nightengale et al., "Understanding Hearing and Hearing Loss in Children With Down Syndrome," *American Journal of Audiology*, vol. 26, no. 3, pp. 301-308, 2017.

[91] K. Neumann et al., "Auditory status of persons with intellectual disability at the German Special Olympic Games: Status auditivo de las personas con discapacidad intelectual en los Juegos Olímpicos Especiales de Alemania," *International journal of audiology*, vol. 45, no. 2, pp. 83-90, 2006.

[92] A. K. Sinha et al., "Hearing screening outcomes for persons with intellectual disability: a preliminary report of findings from the 2005 Special Olympics World Winter Games," *International journal of audiology*, vol. 47, no. 7, pp. 399-403, 2008.

[93] R.N. Dehankar et al. "Prevalence of Congenital Cataract in Patients with Down's Syndrome," *International Journal of Medical and Applied Science*, vol. 3, no. 1, 2014.

[94] B. Haargaard, and H.C. Fledelius, "Down's syndrome and early cataract," *British Journal of ophthalmology*, vol. 90, no. 8, pp. 1024-1027, 2006.

[95] S. Buckley, "Living with Down syndrome," A Publication of The Down Syndrome Educational Trust, 2000.

[96] B.G. Skotko et al., "A predictive model for obstructive sleep apnea and Down syndrome," *American Journal of Medical Genetics Part A*, vol. 173, no. 4, pp. 889-896, 2017.

[97] Rosen, Dennis, "Obstructive sleep apnea in children with Down syndrome," *Sleep Disordered Breathing in Children, Humana Press, Totowa, NJ*, pp. 303-312, 2012.

[98] M.S. Trois et al., "Obstructive sleep apnea in adults with Down syndrome," *Journal of clinical sleep medicine*, vol. 5, no. 4, pp. 317-323, 2009.

[99] A.J. Esbensen, "Health Conditions Associated with Aging and End of Life of Adults with Down Syndrome," *International review of research in mental retardation*, vol. 39, pp. 107-126, 2010.

[100] G. Alsuhaibani et al., "76. Profile and spectrum of congenital heart defect in pediatric patient with down syndrome," *Journal of the Saudi Heart Association*, vol. 28, no. 3, pp. 218-219, 2016.

[101] E. Mihci et al., "Evaluation of congenital heart diseases and thyroid abnormalities in children with Down syndrome," *Anatolian Journal of Cardiology*, vol. 10, no. 5, pp. 440-445, 2010.

[102] P.F. Faria et al., "Association between congenital heart defects and severe infections in children with Down syndrome," *Revista Portuguesa de Cardiologia (English Edition)*, vol. 33, no. 1, pp. 15-18, 2014.

[103] K.J. Dooley, "Congenital Heart Disease and Down Syndrome," Springer International Publishing, Cham, Switzerland, pp. 1301-1310, 2016.

[104] G. Holmes, "Gastrointestinal disorders in Down syndrome," *Gastroenterology and hepatology from bed to bench journal*, vol. 7, no. 1, pp. 6-8, 2014.

[105] A. Jackson et al. "Clinical characteristics of dysphagia in children with Down syndrome." *Dysphagia*, vol. 31, no. 5, pp. 663-671, 2016.

[106] M. Matinelli, A. Staiano A., "Motility Problems in Developmental Disorders: Cerebral Palsy, Down Syndrome, Williams Syndrome, Autism, Turner's Syndrome, Noonan's Syndrome, Rett Syndrome, and Prader-Willi Syndrome," Pediatric Neurogastroenterology, Springer International Publishing, pp. 303-309, 2017.

[107] E. Pilcher, "Dental care for the patient with Down syndrome," *Down syndrome research and practice*, vol. 5, no. 3, pp. 111-116, 1998.

[108] J.E. Hall, "Guyton and Hall Textbook of Medical Physiology E-Book," Elsevier Health Sciences, 2015.

[109] W.F. Boron, and E.L. Boulpaep, "Medical Physiology," 2nd Edition, Elsevier Health Sciences, 2012.

[110] M.J. Pierce et al., "Characterization of Thyroid Abnormalities in a Large Cohort of Children with Down Syndrome," *Hormone Research in Paediatrics*, vol. 87, no. 3, pp. 170-178, 2017.

[111] M.E. Percy, and W.J. Lukiw, "Is heart disease a risk factor for low dementia test battery scores in older persons with Down syndrome? Exploratory, pilot study, and commentary," *International Journal of Developmental Disabilities*, pp. 1-14, 2017.

[112] E. Head et al., "Alzheimer's disease in Down syndrome," *European journal of neurodegenerative disease*, vol. 1, no. 3, pp. 353-364, 2012.

[113] I. Khan, S. Malinge, and J. Crispino, "Myeloid leukemia in Down syndrome," *Critical Reviews™ in Oncogenesis*, vol. 16, no. 1-2, pp. 25-36, 2011.

[114] S.A. So, R.C. Urbano, and R.M. Hodapp, "Hospitalizations of infants and young children with Down syndrome: evidence from inpatient person-records from a statewide administrative database," *Journal of Intellectual Disability Research*, vol. 51, no. 12, pp. 1030-1038, 2007.

[115] W.F. Sullivan et al., "Primary care of adults with intellectual and developmental disabilities: 2018 Canadian consensus guidelines," *Canadian Family Physician*, vol. 64, no. 4, pp. 254-279, 2018.

[116] V. Covelli et al., "Family members and health professionals' perspectives on future life planning of ageing people with Down syndrome: a qualitative study," *Disability and rehabilitation*, vol. 40, no. 24, pp. 2867-2874, 2018.

[117] P.G. Blasco et al., "Overcoming challenges in primary care in Brazil: successful experiences in family medicine education," *Education for Primary Care*, vol. 29, no. 2, pp. 115-119, 2018.

[118] B. Skotko, and R.C. Bedia, "Postnatal support for mothers of children with Down syndrome," *Mental Retardation*, vol. 43, no. 3, pp. 196-212, 2005.

[119] J. Marshall et al., "Services and supports for young children with Down syndrome: parent and provider perspectives," *Child: care, health and development*, vol. 41, no. 3, pp. 365-373, 2015.

[120] S.L. Boulet et al., "Health care expenditures for infants and young children with Down syndrome in a privately insured population," *The Journal of pediatrics*, vol. 153, no. 2, pp. 241-246, 2008.

[121] S. Benner, "A History of Control Engineering," (1993).

[122] F.G. Banica, "Chemical sensors and biosensors: fundamentals and applications," John Wiley & Sons, 2012.

[123] V. Shnayder et al., "Sensor networks for medical care," *Division of Engineering and Applied Sciences-Harvard University*, 2005.

[124] M. Popescu, "Early illness detection in elderly using sensor networks: a review of the TigerPlace experience," *E-Health and Bioengineering Conference (EHB), IEEE*, pp. 1-6, 2015.

[125] T. Hassan, and S. Chatterjee, "A taxonomy for RFID," *Proceedings of the 39th Annual Hawaii International Conference on System Science (HICSS'06), IEEE*, vol. 8, 2006.

[126] A.D. Smith, "Evolution and acceptability of medical applications of RFID implants among early users of technology," *Health marketing quarterly*, vol. 24, no. 1-2, pp. 121-155, 2008.

[127] P.R. Troyk, "Injectable electronic identification, monitoring, and stimulation systems," *Annual Review of Biomedical Engineering*, vol. 1, no. 1, pp. 177-209, 1999.

[128] S.F. Wamba, A. Anand, and L. Carter, "A literature review of RFID-enabled healthcare applications and issues," *International Journal of Information Management*, vol. 33, no. 5, pp. 875-891, 2013.

[129] N. Kumar et al., "An intelligent RFID-enabled authentication scheme for healthcare applications in vehicular mobile cloud," *Peer-to-Peer Networking and Applications*, vol. 9, no. 5, pp. 824-840, 2016.

[130] TE Connectivity Company, "Wearable Sensors," official web site: https://www.te.com/usa-en/industries/sensor-solutions/applications/sensor-solutions-for-consumer-wearable-applications.html?source=header-match&tab=pgp-story. (Accessed on: 09/03/2018).

[131] G. Marmaropoulos, and C. Van Heerden, "Selectively applied wearable medical sensors," *U.S. Patent no. 6,755,795*, 2004.

[132] Y. Charlon, E. Campo, and D. Brulin, "Design and evaluation of a smart insole: Application for continuous monitoring of frail people at home," *Expert Systems with Applications*, vol. 95, pp. 57-71, 2018.

[133] B. Hunt, and J. Taylor, "Systems and methods for obtaining medical information," *U.S. Patent No. 9,886,730*, 2018.

[134] C.T Lin et al., "Wireless and wearable EEG system for evaluating driver vigilance," *IEEE Transactions on biomedical circuits and systems*, vol. 8, no. 2, pp. 165-176, 2014.

[135] D. Konstantas, "Section 4: Sensor, Signal and Imaging Informatics: An overview of wearable and implantable medical sensors," *Yearbook of medical informatics*, vol. 16, no. 1, pp. 66-69, 2007.

[136] X. Yi et al., "Privacy protection for wireless medical sensor data," *IEEE transactions on dependable and secure computing*, vol. 13, no. 3, pp. 369-380, 2015.

[137] Y. Liu et al., "Flexible, Stretchable Sensors for Wearable Health Monitoring: Sensing Mechanisms, Materials, Fabrication Strategies and Features," *Sensors*, vol. 18, no. 2, 2018.

[138] M. Haghi, K. Thurow, and R. Stoll, "Wearable devices in medical internet of things: scientific research and commercially available devices," *Healthcare informatics research*, vol. 23, no. 1, pp. 4-15, 2017.

[139] S.D. Bao, Y.T. Zhang, and L.F. Shen, "Physiological signal based entity authentication for body area sensor networks and mobile healthcare systems," *in 2005 IEEE Engineering in Medicine and Biology 27th Annual Conference*, pp. 2455-2458, 2006.

[140] X. Wang, Z. Liu, and T. Zhang, "Flexible sensing electronics for wearable/attachable health monitoring," *Small*, vol. 13, no. 25, 2017.

[141] G. Mokhtari et al., "Non-wearable human identification sensors for smart home environment: a review," *Sensor Review*, vol. 38, no. 3, pp. 391-404, 2018.

[142] L. Liu et al., "Smart homes and home health monitoring technologies for older adults: A systematic review," *International journal of medical informatics*, vol. 91 pp. 44-59, 2016.

[143] M. Balouchestani, K. Raahemifar, and S. Krishnan, "Concepts for designing low-power wireless sensor networks with compressed sensing theory," *International Conference on Communication and Broadband Networking (ICCBN 2011)*, pp. 47-51, 2011.

[144] J. Yick, B. Mukherjee, and D. Ghosal, "Wireless sensor network survey," *Computer networks*, vol. 52, no. 12, pp. 2292-2330, 2008.

[145] B. Rashid, and M.H. Rehmani, "Applications of wireless sensor networks for urban areas: A survey," *Journal of Network and Computer Applications*, vol. 60, pp. 192-219, 2016.

[146] J. Naganawa et al. "Simulation-based scenario-specific channel modeling for wban cooperative transmission schemes," *IEEE Journal of Biomedical and Health Informatics*, vol. 19, no. 2, pp. 559-570, 2015.

[147] M. Aminian, and H.R. Naji, "A hospital healthcare monitoring system using wireless sensor networks," *Journal of Health & Medical Informatics*, vol. 4, no. 2, 2013.

[148] A.Humayun et al., "Impact on the usage of wireless sensor networks in healthcare sector," *International Journal of Computer Science and Network Security*, vol. 17, no. 4, pp. 102-105, 2017.

[149] Y.F Chung, and C.H. Liu, "Design of a wireless sensor network platform for tele-homecare," *Sensors*, vol. 13, no. 12, pp. 17156-17175, 2013.

[150] T.H. Hsieh et al., "The applications of smart mobile device for detecting balance dysfunction in individuals with down syndrome," *Biomedical Engineering: Applications, Basis and Communications*, vol. 30, no. 1, 2018.

[151] P. Kakria, N.K. Tripathi, and P. Kitipawang, "A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors," *International journal of telemedicine and applications*, vol. 2015, no. 8, 2015.

[152] R.K. Kher, "Mobile and E-Healthcare: Recent Trends and Future Directions," *Journal of Health & Medical Economics*, vol. 2, no. 3, 2016.

[153] J. Zhang et al., "A review of passive RFID tag antenna-based sensors and systems for structural health monitoring applications," *Sensors*, vol. 17, no. 2, 2017.

[154] S. Biswas, R. Das, and P. Chatterjee, "Energy-Efficient Connected Target Coverage in Multi-hop Wireless Sensor Networks," Industry Interactive Innovations in Science, Engineering and Technology, Springer, Singapore, pp. 411-421, 2018.

[155] G. Bu, and M. Potop-Butucaru, "BAN-GZKP: Optimal Zero Knowledge Proof Based Scheme for Wireless Body Area Networks," *Ad Hoc Networks*, vol. 77, pp. 28-41, 2018.

[156] A. Appari, and M.E. Johnson, "Information security and privacy in healthcare: current state of research," *International journal of Internet and enterprise management*, vol. 6, no. 4, pp. 279-314, 2010.

[157] B. Johny, A. Anpalagan, "Body area sensor networks: Requirements, operations, and challenges," *IEEE Potentials*, vol. 33, no. 2, pp. 21-25, 2014.

[158] K.K. Venkatasubramanian, A. Banerjee, and S. Gupta, "PSKA: Usable and secure key agreement scheme for body area networks," *IEEE Transactions on Information Technology in Biomedicine*, vol. 14, no. 1, pp. 60-68, 2010.

[159] H. Al-Tameemi, and T. Ibrahim, "Analyze Medical Image and Compress It by Different Algorithms," *International Journal of Computer Science and Software Engineering*, vol. 6, no. 11, pp. 284-293, 2017.

[160] I. Radojicic, D. Mandic, and D. Vulic, "On the presence of deterministic chaos in HRV signals," *Computers in Cardiology, IEEE*, vol. 28, pp. 465-468, 2001.

[161] S. Zebboudj et al., "Secure and efficient ECG-based authentication scheme for medical body area sensor networks," *Smart Health*, vol. 3-4, pp. 75-84, 2017.

[162] R. Rieger, and J.T. Taylor, "An adaptive sampling system for sensor nodes in body area networks," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 17, no. 2, pp. 183-189, 2009.

[163] M. Elgendi et al., "Improving Remote Health Monitoring: A Low-Complexity ECG Compression Approach," *Diagnostics*, vol. 8, no. 1, 2018.

[164] M. Conti et al., "Internet of Things security and forensics: Challenges and opportunities," *Future Generation Computer Systems*, vol. 78, no. 2, pp. 544-546, 2018.

[165] C. Stergiou et al., "Secure integration of IoT and cloud computing," *Future Generation Computer Systems*, vol. 78, no. 3, pp. 964-975, 2018.

[166] P. Li et al., "Multi-key privacy-preserving deep learning in cloud computing," *Future Generation Computer Systems*, vol. 74, pp. 76-85, 2017.

[167] S. Tonyali et al., "Privacy-preserving protocols for secure and reliable data aggregation in IoT-enabled smart metering systems," *Future Generation Computer Systems*, vol. 78, no. 2, pp. 547-557, 2018.

[168] C.R. Taylor, and C.A. Shue, "Validating security protocols with cloud-based middleboxes," *IEEE Conference on Communications and Network Security (CNS)*, pp. 261-269, 2016.

[169] T. Rault, A. Bouabdallah, and Y. Challal, "Energy efficiency in wireless sensor networks: A top-down survey," *Computer Networks*, vol. 67, pp. 104-122, 2014.

[170] A.M. Fernandes, A. Pai, and L.M.M. Colaco, "Secure SDLC for IoT Based Health Monitor," *2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA), IEEE*, pp. 1236-1241, 2018.

[171] R. Kazlauskaitė, and I. Bučiūnienė, "The role of human resources and their management in the establishment of sustainable competitive advantage," *Inžinerinė ekonomika*, vol. 5, no. 60, pp. 78-84, 2008.

[172] L.C.R. Carpinetti, F.C.A Santos, and M.A. Goncalves, "Human resources and total quality management: case studies in Brazilian companies," *The TQM Magazine*, vol. 10, no. 2, pp. 109-114, 1998.

[173] M.V.G. Da Cruz et al., "The complex interaction between human resources management, the labor market and employment relations in Brazil," *Tourism & Management Studies*, vol. 13, no. 4, pp. 65-72, 2017.

[174] N.A. Abd El-Mawgoud, and S.E. Masry, "Enhancing of Female Rural Leaders' Awareness about First Aid Activities Using Capacity Development Approach," *International Journal of Novel Research in Healthcare and Nursing*, vol. 4, no. 1, pp. 345-353, 2017.

[175] M.A. Carpenter et al., "Principles of management" Flat World, 2009.

[176] A.H. Glenngård, A. Anell, and A. Beckman, "Choice of primary care provider: results from a population survey in three Swedish counties," *Health Policy*, vol. 103, no. 1, pp. 31-37, 2011.

[177] M.S. Arefin, J.M. Redouté, and M.R. Yuce, "Wireless biosensors for POC medical applications," Woodhead Publishing, pp. 151-180, 2017.

[178] S. Naddeo et al., "A Real-time m-Health Monitoring System: An Integrated Solution Combining the Use of Several Wearable Sensors and Mobile Devices," *10th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2017)*, vol. 5, pp. 545-552, 2017.

[179] D. Gomes et al., "XMPP based context management architecture," *In 2010 IEEE Globecom Workshops*, pp. 1372-1377, 2010.

[180] H. Al-Tameemi, "Using dijkstra algorithm in calculating alternative shortest paths for public transportation with transfers and walking," Çankaya Üniversitesi, Master Diss., 2014.