MULTI-CRITERIA DECISION-MAKING ANALYSIS FOR HOSPITAL SELECTION IN THE TELEMEDICINE ENVIRONMENT

OSAMAH SHIHAB AHMED ALBAHREY

UNIVERSITI PENDIDIKAN SULTAN IDRIS

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OSAMAH SHIHAB AHMED ALBAHREY

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ABSTRACT

In this study, a new module for telemedicine architecture, namely Tier 4, was developed to provide intelligent data and services management in the telemedicine environment. For a suitable hospital to provide remote healthcare services, a new hospital selection framework based on multi-criteria decision making (MCDM) of Tier 4 was developed for chronic heart disease patients who lived in remote places. An experiment was conducted on the basis of three stages. Firstly, health data, such as electrocardiogram, oxygen saturation sensor, blood pressure monitor, and non-sensory measurement, were collected from 500 patients with different symptoms. The number of healthcare services representing the hospital status was collected from 12 hospitals located in Baghdad City. A decision matrix based on the crossover of 'multi-healthcare services' and 'hospital list' of Tier 4 was also constructed. Secondly, the hospitals were then ranked using MCDM techniques, namely the integrated Analytic Hierarchy Process (AHP) and Vlsekriterijumska Optimizacija I Kompromisno Resenje (VIKOR). Thirdly, means and standard deviations were computed to ensure hospital ranking could be systematically performed to facilitate objective validation. The results showed that (1) the integration of AHP and VIKOR would able to effectively solve hospital selection problems. (2) In the objective validation, significant differences in scores between groups were observed, indicating that the ranking results were identical. (3) In the evaluation, the results revealed that the proposed framework was more effective by 56.25% than the benchmark framework. In conclusion, hospitals with multiple-healthcare services received the highest ranks compared to those of the hospitals with fewer healthcare services. The implications of this study provide several benefits to medical organizations by balancing the healthcare services loading among hospitals, assist medical teams by performing a timely and accurate treatment for their patients, and provide healthcare services for patients living in unserved or underserved areas.

ANALISIS PEMBUATAN KEPUTUSAN PELBAGAI KRITERIA BAGI PEMILIHAN HOSPITAL DALAM PERSEKITARAN TELEPERUBATAN

ABSTRAK

Dalam kajian ini, satu modul baharu untuk seni bina teleperubatan, iaitu Tier 4, dicadangkan untuk menyediakan data dan pengurusan perkhidmatan pintar dalam persekitaran teleperubatan. Bagi sesebuah hospital menyediakan perkhidmatan penjagaan kesihatan, satu kerangka kerja berdasarkan pembuatan keputusan pelbagai kriteria (MCDM) Tier 4 dibina untuk pesakit jantung kronik yang tinggal di kawasan terpencil. Dalam kajian ini, data kesihatan, seperti elektrokardiogram, sensor ketepuan oksigen, monitor tekanan darah, dan pengukuran bukan sensori, diperoleh daripada 500 pesakit dengan simptom yang berbeza di 12 hospital di Bandaraya Baghdad. Satu matriks keputusan berdasarkan lintasan 'perkhidmatan pelbagai penjagaan kesihatan' dan 'senarai hospital' pada Tier 4 dibangunkan. Kedudukan hospital kemudiannya disusun menggunakan teknik MCDM, iaitu proses Hierarki Analisis Bersepadu (AHP) dan Vlse Kriterijumska Optimizacija Kompromisno Resenje (VIKOR). Min dan sisihan piawai dikira bagi memastikan kedudukan hospital dilakukan secara sistematik bagi pengesahan objektif. Keputusan kajian menunjukkan (1) pengintegrasian AHP dan VIKOR dapat menyelesaikan masalah pemilihan hospital dengan berkesan. (2) Untuk pengesahan objektif, perbezaan signifikan dalam skor antara kumpulan telah dikesan yang menunjukkan keputusan penentuan kedudukan adalah sama. (3) Untuk penilaian, keputusan menunjukkan kerangka kerja yang dicadangkan adalah lebih berkesan sebanyak 56.25% berbanding dengan kerangka kerja tanda aras. Sebagai rumusan, hospital yang menyediakan perkhidmatan penjagaan kesihatan yang pelbagai mendapat kedudukan tertinggi berbanding hospital yang kurang menyediakan perkhidmatan yang sama. Implikasi kajian ini memberi pelbagai manfaat di mana organisasi perubatan dapat mengimbangi bebanan perkhidmatan penjagaan kesihatan, pasukan perubatan dapat menyediakan rawatan yang tepat dan cepat kepada para pesakit, dan para pesakit yang tinggal di kawasan yang tidak dilayani atau tidak terlayani dapat menerima perkhidmatan penjagaan kesihatan yang cepat.

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LIST OF ABBREVIATIONS

MCDM	Multi Criteria Decision Making
CANet	Cane Network
PHC	Portable Health Clinic
MADMHA	Multi Attribute Decision Making Handover Algorithm
AAA	Ambulance Alert Alarm
ACS	Acute Coronary Syndrome
IOV	Internet Of Vehicles
HPSO-OCC	Hierarchical Particle Swarm Optimization with Ortho Cyclic Circles
SOA	Service Oriented Architecture
PSO	Particle Swarm Optimization
PHDA	Priority Based Health Data Aggregation
PTaaS	Physical Therapy-as-a-Service
LCS	Low Cost and Secure
PCSs	Personal Coaching Systems
MSHA	Multi Source Health Architecture
mHealth	Mobile Health
DSSs	Decision Support System
ED	Emergency Department
AAL	Ambient Assisted Live

e-health	Electronic Health
MIMUs	Magnetic and Inertial Measurement Units
QOS	Quality of Service
PHRs	Personal Health Records
EHRs	Electronic Health Records
EMR	Electronic Medical Records
ISO	International Organization for Standardization
HAN	Home Area Network
MCI	Mass Causalities Incidence
IoT	Internet-of-Things
CPS	Cyber- Physical Systems
RBFNN	Radial Basis Function Neural Network
RTPS	Real Time Publish Subscribe
MIs	Medical Institutes
IHE	Integrating Healthcare Enterprise
DM	Decision Making
DSS	Decision Support System
AHP	Analytic Hierarchy Process
MLAHP	Multi-layer Analytic Hierarchy Process
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
VIKOR	VlseKriterijumskaOptimizacija I KompromisnoResenje

ECG	Electrocardiogram
SpO2	Blood Oxygen Saturation Level
BP	Blood Pressure
GDM	Group Decision Making
MAC	Media Access Control
WBAN	Wireless Body Area Network
MEW	Multiplicative Exponential Weighting
WPM	Weighted Product Method
WSM	Weighted Sum Model
SAW	Simple Additive Weighting
HAW	Hierarchical Adaptive Weighting
ANP	Analytic Network Process
PGS	Patient's Guidance System
MAUT	Multi Attribute Utility Theory
WHO	World Health Organization
PIS	Positive Ideal Solution
NIS	Negative Ideal Solution
E-health	Electronic Health
MTS	Manchester Triage System
MBAN	Medical Body Area Network
FAD	False Alarm Detection
EMI	Electromagnetic interference
IMDs	Interoperable Medical Devices
STM	Sacco Triage Method

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter introduces the research topic, the statement of the problem, and research objectives. This chapter also presents the scope of this research where the experimental and technical scopes are explained. A brief background of the research components is presented in Section 1.2. The statement of the problem, on which the direction of the research is based, is identified and introduced in Section 1.3. Research questions are listed in Section 1.4. This is followed by the objectives of the research, which are described in Section 1.5.

The connections amongst research objectives, research questions, the specific and general problem is presented in Section 1.6. Moreover, the scope of the study is discussed in Section 1.7. The significant of the study is presented in Section 1.8. The main structure of the thesis is briefly outlined in Section 1.9. Finally, a summary of the chapter is presented in Section 1.10.

1.2 Research Background

Telemedicine used in healthcare has been growing rapidly because it offers remote healthcare services to patients in distant locations (Rogove, McArthur, Demaerschalk, & Vespa, 2012; Topol, 2015). Telemedicine is a sort of remote medical practice, in which there is the possibility of making different performing actors cooperating and permitting their collaborations efforts in the diagnosis or treatment of a disease (M.B. Doumbouya, Kamsu-Foguem, Kenfack, & Foguem, 2015). The main idea of telemedicine is to provide remote medical services at distance through telecommunication technologies (Moghadas, Jamshidi, & Shaderam, 2008). Remote healthcare services can be beneficial to patients in isolated communities and remote regions, who can receive care from doctors or specialists far away without the patient having to travel to visit them (Gilpin & Gilpin, 2000).

The aging population and the increase in the number of chronic diseases have encouraged society to foster health consciousness among patients, encouraging them to

become “health consumers” looking for an enhanced health management (Touati & Tabish, 2013). The increase in the number of patients is expected to be driven by various causes, particularly population aging, disasters, and mass casualty incidences (MCIs) (Culley, Svendsen, Craig, & Tavakoli, 2014; Fernandes, Wuerz, Clark, & Djurdjev, 1999; Jeong et al., 2012; Kalid et al., 2018; S. H. Li, Cheng, Lu, & Lin, 2012; Omar H Salman, Rasid, Saripan, & Subramaniam, 2014; van Dyk, 2014). The increases in the number of patients lead to a major challenge, which increases the demand for healthcare services given to users. Thereby, the availability of services in hospitals can be decreased at any time according to patients demand that caused limitation in healthcare services and medical resources management (Busse, Schreyögg, & Smith, 2008; Wizig, 2004). However, such challenges increase when patients are far from hospitals and use remote healthcare services (Omar H Salman et al., 2014). Therefore, increasing healthcare services demands have led to the urgent need for effective and scalable healthcare services (Baig & Gholamhosseini, 2013; Rocha et al., 2013). The medical center should effectively use any developed system to accommodate and manage such a growing system demand (Omar H Salman et al., 2014). Regarding hospitals management, few studies have been presented systems for managing dynamic processes of the health organization (Ben Othman et al., 2016), managing patients in ED (Vaidehi et al., 2013), and managing the process of emergency facilities and the implementation of measures to preserve the quality of care for consumers (Bharatula & Meenakshi, 2016). On another hand, several methods have been designed to provide healthcare services, patients who are required for healthcare services are provided from an individual provider (hospital, professional, medical center) of healthcare services (Ganapathy et al., 2013; Ganapathy,

Vaidehi, Kannan, & Murugan, 2014; A. Hussain, Wenbi, da Silva, Nadher, & Mudhish, 2015; Mendes et al., 2014; Miah, Hasan, & Gammack, 2017; Zanjal & Talmale, 2016). Thereby, providing healthcare services to patients through distributed hospitals, as well manage and control the loading of healthcare services between healthcare providers is one possible solution to avoid the limitations of services in hospitals (M.-Y. Chang, Pang, Tarn, Liu, & Yen, 2015; Kalid et al., 2018; Kovalchuk, Krotov, Smirnov, Nasonov, & Yakovlev, 2018; Liu, Long, Li, Tsai, & Kuo, 2001; J. Wang, Qiu, & Guo, 2017).

Remotely healthcare systems in telemedicine have gained considerable attention because of their significant role in the lives of people (Omar H Salman et al., 2014; Sanders, Devergnas, Wichmann, & Clements, 2013). For remote patients, continuous monitoring from a distant hospital is highly desirable to ensure adequate care and provide suitable guidelines for proper medication (Mirkovic, Bryhni, & Ruland, 2012). Moreover, remote patient care is now becoming a subject of major concern in healthcare services (Sarkar & Sinha, 2014). Remote home patients, especially the elderly and chronic heart disease, are at critical risk of harm during a disaster (Wyte-Lake, Claver, & Dobalian, 2016). Thus, manage and control the loading of healthcare services between healthcare providers and providing healthcare services through distributed hospitals is important to support the continuous care of remote patients in a pervasive environment.

1.3 Research Problem

Scalability is the expansion capability of healthcare systems to satisfy the demands of an increasing number of users.

As the number of patients increases, the need for scalability also increases. The increase can occur due to different reasons, including population aging, disasters and mass causality incidents (Jeong et al., 2012; Kalid, et al., 2018; Omar H Salman et al., 2014; van Dyk, 2014). As the number of users increases, the demand for health-care services also increases, which is a major issue in medical centres (Rocha et al., 2013; Omar H Salman et al., 2014). The issues of scalability can be responsible for acute shortage of health-care services and medical resources with increasing healthcare demand (Kalid et al., 2018; Omar H Salman et al., 2014).

Choosing appropriate hospital after evaluating their number of available services to get the treatment based on triage level known as hospital selection (Kalid et al., 2018). The management and control of healthcare services loading amongst hospitals and the provision of quality services to patients from suitable hospitals are important aspects that must be measured or evaluated (Ben Othman et al., 2016; T. H. Chang, 2014; Kalid et al., 2018; Khan, Prasad, & Rajamanoharane, 2010; Kovalchuk et al., 2018; Leister & Stausberg, 2007; Lingsma et al., 2009). Hospital selection is required to avoid limitation and reduce the number of healthcare services in hospitals, but it remains challenging (Kalid et al., 2018; Kovalchuk et al., 2018).

In the existing healthcare systems, patients who are required for healthcare services are provided by traditional services from an individual provider (hospital, professional, medical center) of healthcare services (Ganapathy et al., 2013, 2014; A. Hussain et al., 2015; Mendes et al., 2014; Miah et al., 2017; Zanjal & Talmale, 2016). In addition, several studies have presented systems that healthcare institutions may use to manage the dynamic processes of the health organisation, managing the patients in ED and managing the process of emergency facilities and proposed measures to preserve the quality of care for consumers. In life-critical, limitations that involve numbers of services is undesirable and may cause death (Rezaee, Yaghmaee, Rahmani, & Mohajerzadeh, 2014b). However, this research has not come across any other research that has exclusively worked with the managing and controlling the load on healthcare services amongst hospitals. Therefore, providing healthcare services to patients based on their triage level through distributed hospitals, as well manage and control the loading of healthcare services amongst healthcare providers, becomes especially important to get rid the limitations and acute shortage of services in hospitals (M.-Y. Chang et al., 2015; Kalid et al., 2018; Kovalchuk et al., 2018; Liu et al., 2001; J. Wang et al., 2017). Such decisions, if made appropriately, can save lives, among other advantages.

With the purpose of illuminating the specific problems related to hospital management and selection, three issues have been illustrated in this research. In the first issue, the process involves simultaneous consideration of multiple attributes (healthcare services) for each hospital which considered a multi-attribute decision matrix (Akdag,

Kalaycı, Karagöz, Zülfikar, & Giz, 2014; Faulin, Juan, Grasman, & Fry, 2012). In the second issue, different weights are often given for the attributes by decision makers (doctors) which further increase the complexity of the task (Kalid, Zaidan, Zaidan, Salman, Hashim, & Muzammil, 2018; O. H. Salman, Rasid, Saripan, & Subramaniam, 2014). Moreover, such a selection process involves simultaneous consideration of the healthcare services numbers from multiple attributes generate a data variation that considered the third issue (Albahri, Zaidan, Albahri, Zaidan, & Alsalem, 2018).

Consequently, hospital management and selection process amongst hospitals to manage health-care services and choose the most suitable hospital for patients with chronic heart disease are considered a complicated multi-attribute decision problem. In this scenario, every hospital is deemed an alternative for the decision maker. These processes question how hospitals can be ranked to manage hospital services and provide health-care services from the suitable hospital. These concerns, which are directly related to patients' lives, are our research problems. The problem statement configuration is illustrated in Figure 1.1.

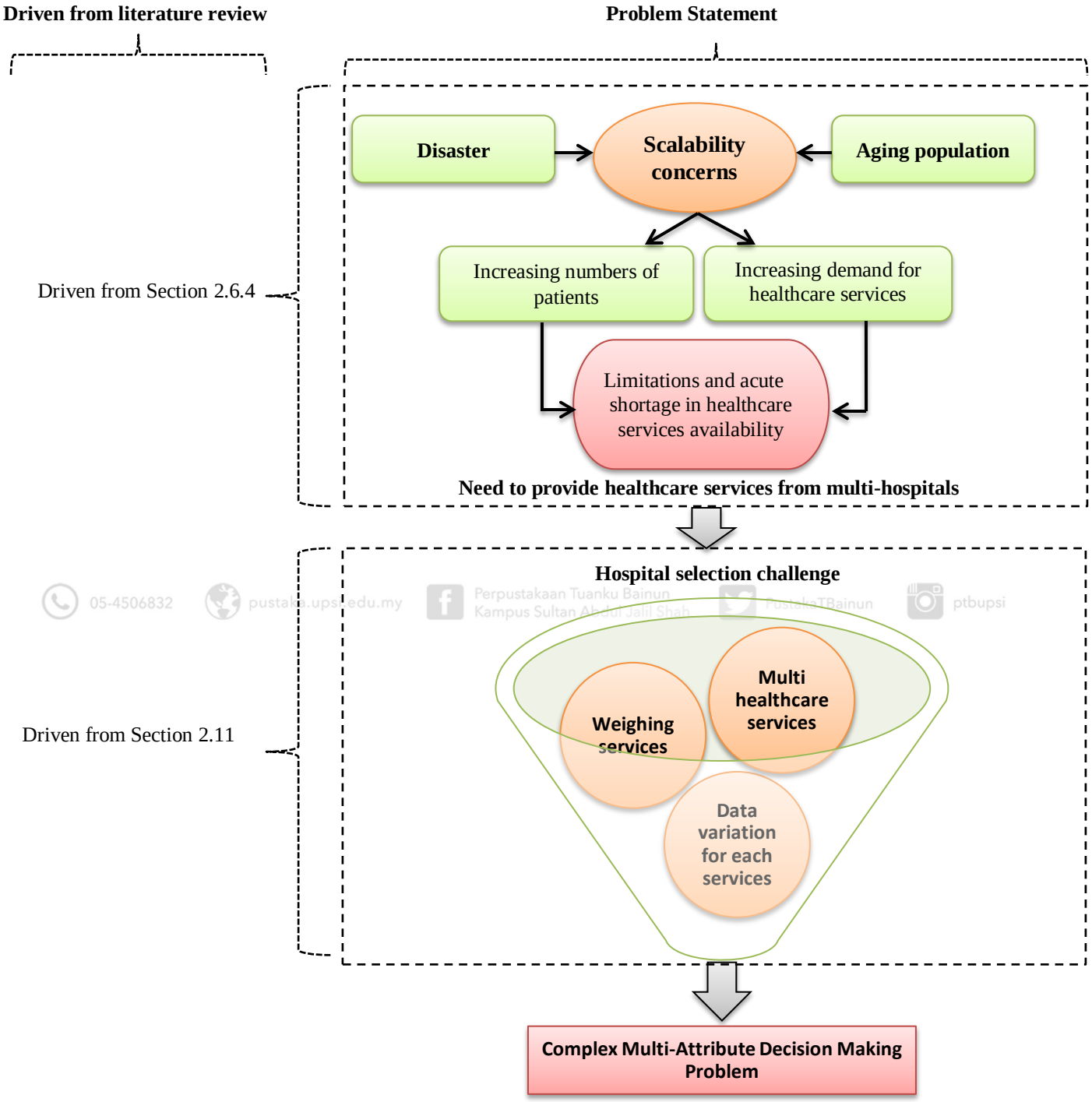

Figure 1.1 Problem Statement Configurations

1.4 Research Qustiones

1. What are the available technologies of healthcare services provision?
2. What are the requirements needed to constructs hospital selection framework in the telemedicine environment?
3. Is the process of healthcare service provision in the current telemedicine architecture appropriate?
4. Are the existing triage standards and guideline can use to categorise and localise healthcare services for patients with heart chronic disease?
5. Is there any integrated platform containing ‘multi-healthcare services’ and ‘hospital list’ in the existing technologies?
6. What are the suitable techniques to develop a framework for hospital selection?
7. Does the proposed hospital selection framework is valid systematically?
8. Does the performance of the proposed hospital selection framework is better than other works?

1.5 Research Objectives

The objectives of this research are listed as follows:

1. To investigate the existing technologies of healthcare services provision within telemedicine applications and highlight weaknesses.
2. To propose a new intelligent data and services management (Tier4) module to the telemedicine architecture for healthcare services provision.
3. To propose a new remote triage and package localization module for patients with heart chronic disease based on the proposed Tier 4 module.
4. To identify a decision matrix module for ‘multi-healthcare services’ and ‘hospital list’ based on the proposed triage and package localization module.
5. To develop a hospital selection framework based on the identified decision matrix module.
6. To validate and evaluate the developed hospital selection framework.

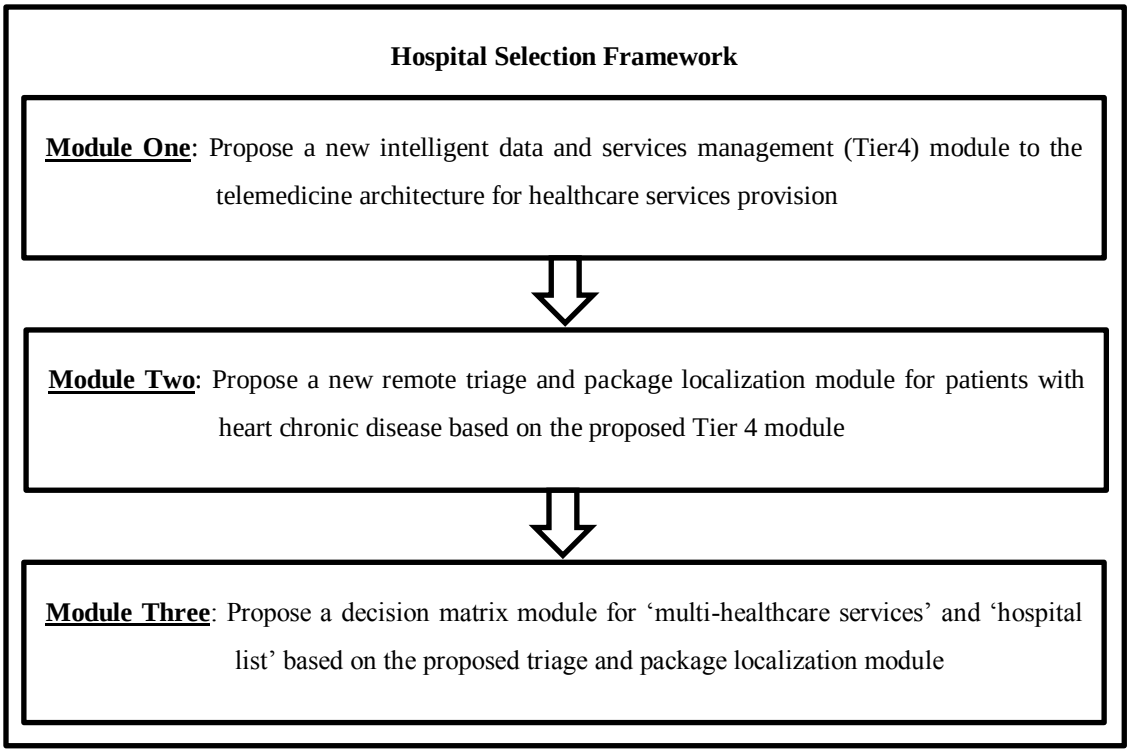

Figure 1.2 Hospital Selection Framework Based on Three Modules

1.6 Connections among Research Objectives, Questions, and Problems

In this section, all research questions have been answered by the research objectives. Each objective is linked to one or two questions. As well as, the specific and general problem are linked to more than one research objectives and questions. Table 1.1 below presents the connection amongst research objectives, research questions, the specific problem, and general problem.

Table 1.1

Connection amongst Research Objectives, Questions, and Problems

Research objectives	Research questions	Specific problem	General problem
1. To investigate the existing technologies of healthcare services provision within telemedicine applications and highlight weaknesses.	1. What are the available technologies of healthcare services provision? 2. What are the requirements needed to constructs hospital selection framework in the telemedicine environment?		
2. To propose a new intelligent data and services management (Tier4) module to the telemedicine architecture for healthcare services provision.	3. Is the process of healthcare service provision in the current telemedicine architecture appropriate?		
3. To propose a new remote triage and package localization module for patients with heart chronic disease based on the proposed Tier 4 module.	4. Are the existing triage standards and guideline can use to categorise and localise healthcare services for patients with heart chronic disease?	Multi-criteria (multi-healthcare services for hospital selection)	Hospital selection and management problem
4. To identify a decision matrix module for 'multi-healthcare services' and 'hospital list' based on the proposed triage and package localization module.	5. Is there any integrated platform containing 'multi-healthcare services' and 'hospital list' in the existing technologies?		
5. To develop a hospital selection framework based on the identified decision matrix module.	6. What are the suitable technique for develop a framework for hospital selection? 7. Does the proposed hospital selection framework is valid systematically?	- Importance criterion - Data variation	
6. To validate and evaluate the developed hospital selection framework	8. Does the performance of the proposed hospital selection framework is better than other works?		

Table 1.1 shows, the first objective is answered the first two questions, the second objective is answered the third question, the third objective is answered the fourth question, the fourth objective is answered the fifth question, the fifth objective is answered the sixth question, and the last objective is answered the seventh and eighth questions. Moreover, one specific problem which is 'multi-healthcare services for hospital selection' is linked to three objectives and questions, while two specific problems, namely, 'importance criterion' and 'data variation' are linked to one objective and question. Finally, the general problem of this research which is 'hospital selection and management problem' is linked to four research objectives and questions.

1.7 Research Scope

This research is a cross-domain involving healthcare services and expert system algorithms. The research was designed to solve the problem of healthcare services provision for remote patients for telemedicine environment. Different research methods are involved in the study because the problem is classified as a multi-disciplinary problem. The case study in which chronic heart diseases are used in the experiments to adjust the settings and the parameters of the healthcare services used for weighting and selection.

The outcomes of the research indicate the research type. Two outputs are expected from this study. One is a framework performed via several steps that improve

the process of hospitals' selection for chronic heart disease patients for telemedicine environment. The other one is a complete guideline for selection of hospitals that can accommodate the development in this area.

Furthermore, the integrated MCDM method in Tier 4 represents the improvements in the performance of the telemedicine system from the perspective of software development. The proposed method has been validated statistically; moreover, various scenarios and checklist benchmarking have been presented to evaluate the proposed framework. The general scheme for our research and the view that represents the research method, research type, and research domain are presented in Figure 1.2.

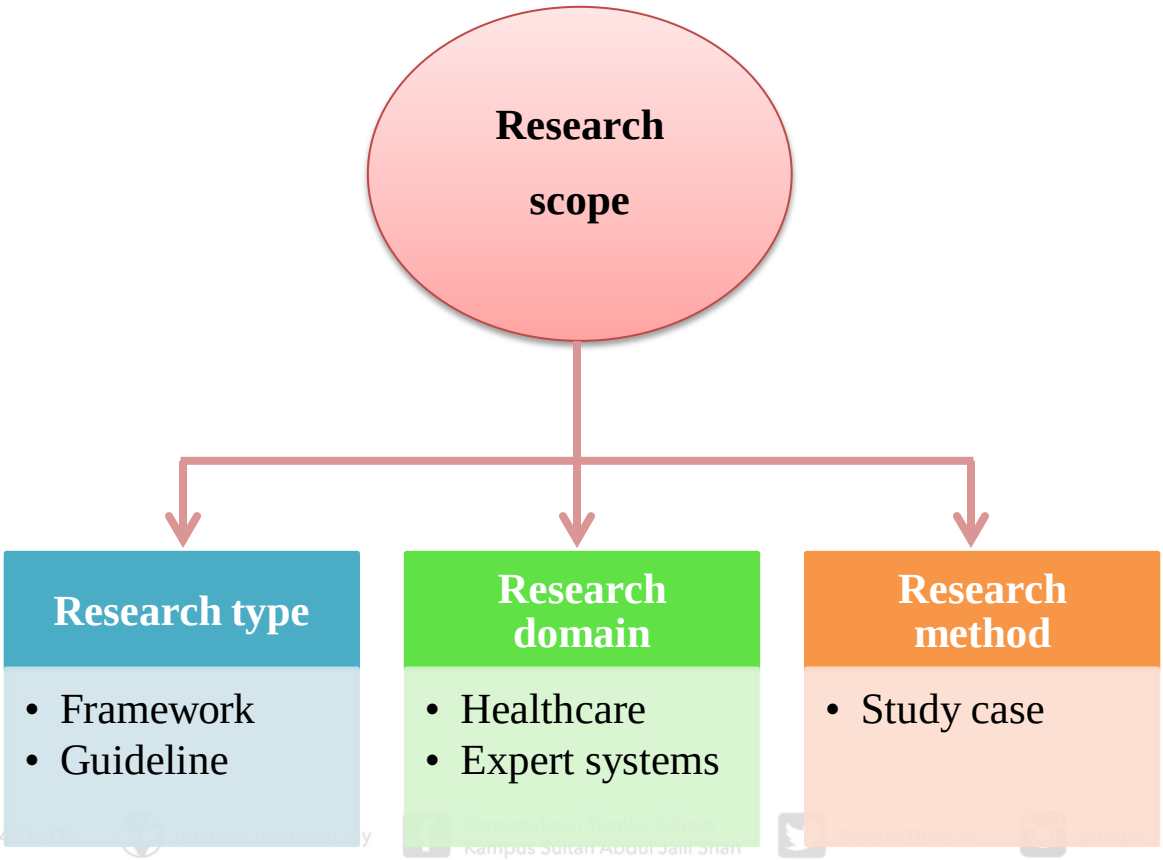

Figure 1.3 General Scheme and Scope of the Study

1.8 Significant of the Study

The field of telemedicine has been developed rapidly because it offers obvious and compelling benefits. In this section, we present the benefits and significance of this research, which are organised into three categories according to related benefits. The corresponding significant are presented for further discussion (Figure 1.2).

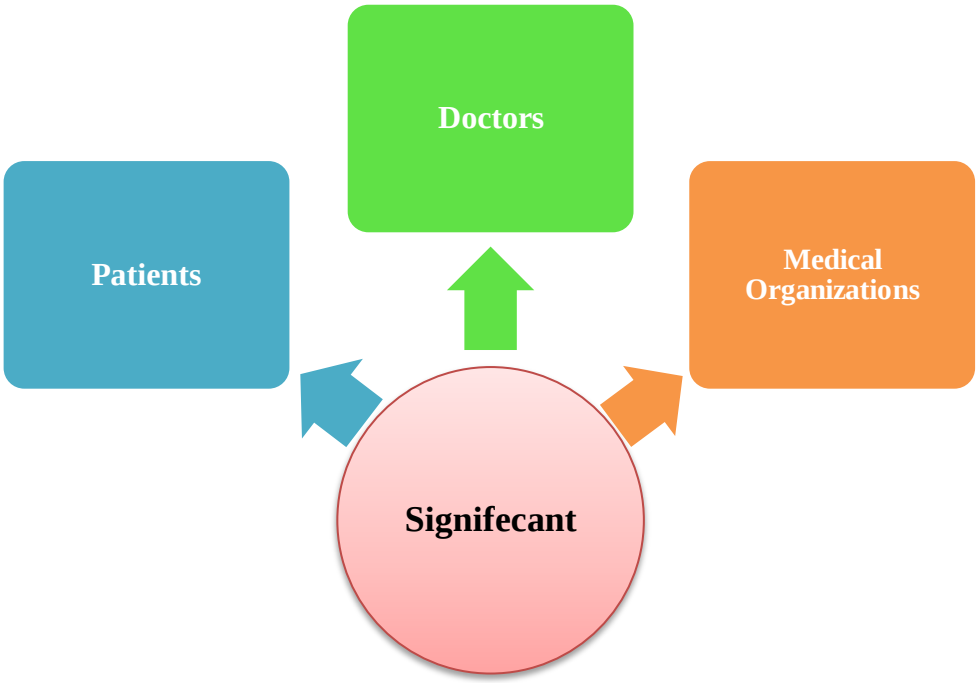

Figure 1.4 Significant Categories of the Study

1.8.1 Benefits to Patients

EDs in hospitals are places where a large number of people must be attended in a short time and where critical situations are expected to emerge. When a patient arrives at the ED, they need to be classified according to the seriousness of their conditions. A healthcare application remotely recognises patients with the most acute emergency case; the patient with the most acute emergency case is the first to obtain a response from the server (Ganapathy et al., 2014; Hindia, Rahman, Ojukwu, Hanafi, & Fattouh, 2016; Moreno et al., 2016; Omar H Salman et al., 2014). A healthcare monitoring system can be used for health monitoring, particularly of the elderly and persons with disabilities and

provide them with a service-oriented emergency response when they suffer abnormal health conditions (A. Hussain et al., 2015; Peleg et al., 2017). Telemedicine services can effectively improve the quality of healthcare in large centres and deliver these services to unserved and underserved areas. A healthcare system can be used to recognise and decrease morbidity by providing health consultations in unreached areas (Rajkumar & Sriman Narayana Iyengar, 2013; Sakuragui, Rebelo, Gutierrez, Näslund, & Håkansson, 2013; Zanjal & Talmale, 2016). Finally, this research ensure continues healthcare services to patients with heart chronic disease by balancing and controlling healthcare services amongst hospitals in case of natural disasters, and the aging population.

1.8.2 Benefits to Medical Organizations

Managing healthcare organisations is complex owing to the dynamic operations and distribution of hospitals (Kalid et al., 2018). Thus, healthcare institutions must focus on this issue to meet the requirements of patients (Albahri et al., 2018). Moreover, this research can manages the complex hospitals and their dynamic processes. Moreover, this research can be gain the benefits to medical organizations to manage and balance the healthcare services amongst hospitals in case of scalability challenges. Provide a way to improve the triage and healthcare services provision processes for the healthcare organizations constantly making difficult resource decisions is another benefit of this research.

1.8.3 Benefits to Doctors

In a mass casualty situation, the emphasis shifts from ensuring the best potential outcome for each individual patient to ensuring the best potential outcome for the greatest number of patients, helping medical teams acquire real-time information of multiple casualties for timely and accurate treatment and enabling rapid and optimal resource assignment according to the seriousness of the status of the patients' status (Beck & Georgiou, 2016; Besaleva & Weaver, 2013; Niswar et al., 2013, 2015; Paulus et al., 2015; Renner et al., 2014; Rodriguez et al., 2014; Santos, Blard, Oliveira, & Carvalho, 2015; Ullah, Khelil, Sheikh, Felemban, & Bojan, 2013).

Tele-expertise can assist knowledge sharing and decision support among physicians across organisational and geographical boundaries. Such a task is complex and important, and it is the core of the cooperation among telehealth, health professionals, and medical professionals; this cooperation enables them to make suitable decisions for patient diagnosis or treatment and effectively manage the medical information of their patients (M.B. Doumbouya et al., 2015; Mamadou Bilo Doumbouya, Kamsu-Foguem, Kenfack, & Foguem, 2014; Sene, Kamsu-foguem, & Rumeau, 2015; Tegegne & (Theo) van der Weide, 2014; Urovi, Jimenez-del-Toro, Dubosson, Ruiz Torres, & Schumacher, 2017). Moreover, assist medical teams to gain real-time information of heart chronic disease to perform a timely and accurate treatment of their patients. Finally, this research can be significant for doctors to assist medical teams through providing a decision

making support for triage and healthcare services provision and perform a timely and accurate treatment of their patients.

1.9 Research Organization

This research is composed of six chapters. These chapters are briefly reviewed as follow:

Chapter 1 provides the research background, research problem. Moreover, this chapter demonstrates the research questions, objectives, and the connections among research objectives, research questions, specific problem, and general problem. This chapter also presents the research scope and significant of the study.

Chapter 2 reviews a systematic review protocol for the area of telemedicine applications, followed by an overview of; sensor based (Tier 1), gateway based (Tier 2), and server-based (Tier 3). Heart chronic disease in remote health monitoring also reviewed, followed by the main medical sensors and sources involved in common chronic diseases monitoring. This chapter also examines and reviewed the triage systems, standards, and guidelines, followed by healthcare services packages. Moreover, open issues of evaluation and selection hospital are presented. This chapter ends with technical analyses to the research problems and highlights what should be done to solve those problems.

Chapter 3 gives the full description of the research methodology, which consists of four phases, namely, preliminary study phase, identification phase, development phase, and validation phase. Each phase corresponds and addresses to one or more research objectives.

Chapter 4 presents the results based on the proposed framework in several sections. Each section has its own aims. These sections show the results of the patients' data presentation and (RTPL) algorithm, hospital dataset statuses and decision matrixes, weight measurement and VIKOR results for package 1, 2 and 3.

Chapter 5 presents the results of validating and evaluating the proposed framework, in this chapter, several steps have been involved in the validation and evaluation processes in order to validate and evaluate the performance of the hospital selection framework for telemedicine environment to overcome the research problems.

Chapter 6 presents the research goals attained, contribution, limitation, and conclusion. The areas to be pursued as future works are also suggested in this chapter.

1.10 Chapter Summary

This chapter provides a background about the management of healthcare services, healthcare services provision, hospital selection process, and the remote monitoring over telemedicine. In the statement of the problem, the hospital selection determined as a complex decision-making problem with multiple services from distributed hospitals. The main goal of this research is to improve the management of healthcare services among hospitals, and healthcare services provision by introducing hospital's selection process, and the specific objectives are also discussed. Research questions of this study are listed in this chapter. Moreover, the extent and constraints of this study are elaborated. Moreover, this chapter presented the benefits and significant of this research, which are organised into three categories according to related benefits. The final part of this chapter presented the general idea of the other chapters of this thesis.