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NOVEL TECHNIQUE FOR REORGANISATION OF OPINION ORDER TO INTERVAL LEVELS FOR SOLVING SEVERAL INSTANCES REPRESENTING PRIORITISATION IN PATIENTS WITH MULTIPLE CHRONIC DISEASES

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Alhamdulillah, first and foremost, praise be Allah, the Cherisher and Sustainer of the World and to the Prophet Muhammad (Peace and Blessings of Allah Be upon Him) who was sent by Allah to be a great teacher to the mankind.

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ABSTRACT

Telemedicine has been increasingly used in healthcare to provide services to patients remotely. However, prioritizing patients with multiple chronic diseases (MCDs) in the telemedicine environment is challenging due to the complexity of decision-making based on the different degrees of emergency of such patients. As such, this study was carried out to propose a novel technique called Technique for Reorganization of Opinion Order to Interval Levels (TROOIL) to prioritize patients with MCDs in real-time using a remote health-monitoring system. The proposed TROOIL technique comprises six steps for prioritizing MCD patients, namely the conversion of actual data into intervals, generation rule, ordering rule, expert-rule validation, data reorganization, criteria weighting, and ranking alternatives for each rule. A secondary dataset of 500 remote patients with three chronic diseases, namely chronic heart disease, high blood pressure, and low blood pressure, was adopted from the most relevant prioritization study. The findings showed that the proposed TROOIL was able to prioritize MCD patients effectively, as those with a high degree of emergency were given top priority. For the objective validation, the comparison indicated that the first group's scores were the highest for all rules, indicating that the ranking results were identical. For the evaluation of all scenarios, the performance of the proposed technique exceeded that of the benchmark by 22.95%. In conclusion, the proposed TROOIL technique can effectively deal with multiple decision-making problems in prioritizing MCD patients. As such, this novel technique can be used to help healthcare centers to provide prompt services to MCD patients based on their level of priority, to assist medical organizations to improve the priority setting processes, and to provide medical doctors with decision-making support in prioritizing their patients for timely and accurate treatments.

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KAEDAH BARU PENYUSUNAN SEMULA ARAHAN PENDAPAT KEPADA ARAS SELAAN UNTUK MENENTUKAN KEUTAMAAN PESAKIT KRONIK

ABSTRAK

Teleperubatan semakin digunakan dalam penjagaan kesihatan untuk menyediakan perkhidmatan kepada pesakit secara jauh. Namun, menentukan keutamaan pesakit dengan penyakit kronik dalam persekitaran teleperubatan ada mencabar disebabkan kerumitan dalam membuat keputusan berdasarkan darjah kecemasan para pesakit berkenaan. Oleh yang demikian, kajian ini dijalankan untuk memperkenalkan satu teknik baru yang dinamakan Technique for Reorganization of Opinion Order to Interval Levels (TROOIL) yang boleh digunakan untuk menentukan keutamaan pesakit-pesakit kronik dalam masa nyata dengan menggunakan sistem pemantauan jauh. Teknik TROOIL yang dicadangkan mempunyai enam langkah untuk menentukan keutamaan pesakit kronik, iaitu penukaran data sebenar kepada data selaan, peraturan penjanaan, peraturan penyusunan, pengesahan pakar, organisasi semula data, kriteria pemberatan, dan pemeringkatan alternatif bagi setiap peraturan. Satu set data sekunder terdiri daripada 500 pesakit yang mempunyai penyakit kronik, iaitu penyakit jantung, tekanan darah tinggi, dan tekanan darah rendah, diadaptasikan dari sebuah kajian penentuan keutamaan yang terkini. Dapatan menunjukkan teknik TROOIL yang dicadangkan dapat menentukan keutamaan pesakit kronik dengan berkesan di mana mereka yang mempunyai darjah kecemasan yang tinggi diberikan keutamaan yang tinggi. Bagi pengesahan objektif, perbandingan menunjukkan skor kumpulan pertama adalah tertinggi untuk semua peraturan, dan ini memperlihatkan kesemua keputusan pemeringkatan adalah sama. Bagi penilaian dalam semua senario, prestasi teknik TROOIL adalah melebihi prestasi penanda aras sebanyak 22.95%. Sebagai kesimpulan, teknik TROOIL yang dicadangkan boleh digunakan untuk menangani masalah dalam membuat pelbagai keputusan yang berkaitan dengan penentuan keutamaan pesakit kronik. Oleh yang demikian, teknik baru ini boleh digunakan untuk membantu pusat penjagaan kesihatan dalam menyediakan perkhidmatan yang pantas kepada pesakit kronik berdasarkan tahap keutamaan mereka, membantu organisasi perubatan dalam memperbaiki proses penentuan keutamaan, dan menyediakan sokongan kepada doktor perubatan dalam menentukan tahap keutamaan pesakit mereka bagi mendapatkan rawatan yang cepat dan tepat.

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LIST OF ABBREVIATIONS

AAL	Ambient Assisted Live
AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
BP	Blood Pressure
BWM	Best-Worst Method
CHD	Chronic Heart Disease
CHDs	Chronic Heart Diseases
DM	Decision Making
ECG	Electrocardiogram
ED	Emergency Department
e-health	Electronic Health
E-health	Electronic Health
EHRs	Electronic Health Records
EMI	Electromagnetic Interference
EMI	Electromagnetic interference
FAD	False Alarm Detection
FCFS	First Come First Serve'
HAW	Hierarchical Adaptive Weighting
IMDs	Interoperable Medical Devices
IoT	Internet-of-Things
KSFs	Key Success Factors
MAC	Media Access Control
MAIRCA	Multi-Attribute Ideal-Real Comparative Analysis
MBAN	Medical Body Area Network
MCDA	Multiple-Criteria Decision Analysis
MCDM	Multiple-Criteria Decision-Making
MCDs	Multiple Chronic Diseases

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MCIs	Mass Casualty Incidences
MEW	Multiplicative Exponential Weighting
mHealth	Mobile Health
MSHA	Multi Source Health Architecture
MTS	Manchester Triage System
MUI	Mobile User Interface
NIS	Negative Ideal Solution
PHRs	Personal Health Records
PIS	Positive Ideal Solution
QOS	Quality of Service
RHM	Remote Health Monitoring
RHMSs	Remote Health Monitoring Systems
SAW	Simple Additive Weighting
SpO2	Blood Oxygen Saturation Level
STM	Sacco Triage Method
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
TROOIL	Technique for Reorganising Opinion Order to Interval Levels
VIKOR	VlseKriterijumska Optimizacija I Kompromisno Resenje
WBANs	Wireless Body Area Networks
WHO	World Health Organization
WPM	Weighted Product Method
WSM	Weighted Sum Model

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CHAPTER 1

INTRODUCTION

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1.1 Introduction

This chapter introduces the research topic, statement of the problem and research objectives. It 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, followed by the objectives of the research described in Section 1.5. The connections among research objectives and research questions are presented in Section 1.6. Furthermore, the scope of the study is discussed in Section 1.7.

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The significance of the study is presented in Section 1.8, followed by the main structure of the thesis 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 remote medical practice in which different healthcare providers cooperate and permit their collaborative efforts in the diagnosis or treatment of a disease (M. B. Doumbouya, Kamsu-Foguem, Kenfack, & Foguem, 2015). The goal of telemedicine is to provide medical services at remote areas through telecommunication technologies (Moghadas, Jamshidi, & Shaderam, 2008). Remote healthcare services can be beneficial to patients living in isolated communities and far-flung regions, given that they can receive professional care from physicians or specialists who travel to visit them (Gilpin & Gilpin, 2000).

Triage in telemedicine is the concept of sorting patients in order of treatment necessity in a large-scale emergency. In other words, it is the process of assessing and prioritising care for all patients and casualties (O. H. Salman, Rasid, Saripan, & Subramaniam, 2014). A prioritisation process is often conducted to ensure that care is given in a suitable and timely method (Seising & Tabacchi, 2013). Early identification of critically ill patients and stratification into priority levels upon acceptance to the

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emergency department (ED) are necessary for the quality and integrity of emergency medicine (Acampora, Cook, Rashidi, & Vasilakos, 2013; Rocha, Martins, Freire, et al., 2013). Hence, patient prioritisation aims to identify patients who can safely wait and those who cannot (Brown & Clarke, 2014). Patient prioritisation improves fairness and decreases urgent patients' waiting times. In addition, it can affect the distinctions among areas because it efficiently appropriates available resources within each region (Román et al., 2008; Tebé et al., 2015). Patients' case must be the main tool in assessing their priority according to medical guidelines (Polk, Walker, & Bhatia, 2007).

The common impact of increasing life expectancy and population old age will certainly be the increase in the societal burden of chronic diseases among future older populations (Parekh, Goodman, Gordon, & Koh, 2011). The aging population and the increase in the number of chronic diseases have encouraged society to foster health awareness among patients, emboldening them to become 'health consumers' looking for an enhanced health administration (Touati & Tabish, 2013). The increase in the number of patients is predicted to be driven by different reasons, particularly aging population, disasters and mass casualty incidences (MCIs). Moreover, these challenges increase when patients are far from hospitals and utilise remote healthcare services (O. H. Salman et al., 2014). One possible solution to these problems is that patients need to be prioritised remotely to acquire services and treatments by effective healthcare systems (O. H. Salman et al., 2014; Tebé et al., 2015).

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Different prioritisation methods have been designed to prioritise patients with chronic heart disease (CHD) living in remote regions. The previously proposed prioritisation solution can address prioritisation in patients with single chronic disease only. Furthermore, multi source healthcare architecture (MSHA) enhances efficiency of healthcare scalability by assisting remote prioritisation and triaging patients with CHDs (O. H. Salman et al., 2014). The patients are prioritised using a priority code (PC) with a range of 0–100. Only patients who are part of this range can be prioritised. Meanwhile, those with the same PC value were sorted in a descending order by applying the 'first come, first serve' (FCFS) approach. Moreover, a new approach based on multiple-criteria decision-making (MCDM) techniques was presented to prioritise large-scale data of patients with CHDs by using body sensors during disasters and peak seasons (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018).

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However, to our knowledge, an exclusive presentation of solution for remote prioritisation in a large scale of patients with multiple chronic diseases (MCDs), especially with the application of telemedicine, has not yet been reported (Tier 3).

Remote healthcare prioritisation systems have gained considerable attention because of their significant role in the lives of people (Omar H Salman, Rasid, Saripan, & Subramaniam, 2014; Sanders, Devergnas, Wichmann, & Clements, 2013). Remote prioritisation means triaging patients and identifying their priority for the treatment and transportation to hospitals after evaluating the patients' vital signs (Sakanushi et al., 2013). For remote patients, continuous monitoring from a distant

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hospital is highly desirable to ensure adequate care and provide suitable guidelines for proper medication (Mirkovic, Bryhni, & Ruland, 2012). Moreover, remote patient care is currently becoming a major concern in healthcare services (Sarkar & Sinha, 2014). Patients with multiple chronic conditions (e.g. CHD, chronic blood pressure [BP] disease, fall detection and diabetes) are at great risk of experiencing poor daily functioning (Kalid et al., 2018). MCDs contribute to frailty and disability. Functional limitations often complicate access to healthcare, interfere with self-management and necessitate reliance on caregivers (Services, 2010). Remote home patients, especially the elderly with MCDs, are at critical risk of harm in various situations (Kalid, Zaidan, Zaidan, Salman, Hashim, & Muzammil, 2018). Thus, prioritisation processes for MCDs are important to support the continuous care of remote patients in a pervasive environment.

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1.3 Research Problem

Scalability is the ability of a healthcare application to expand to meet the increased demands by users. Scalability issue arises when the number of patients expectedly increases in several aspects, such as population aging, disasters and MCIs (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018; Omar H Salman et al., 2014; Sangjin Jeong et al., 2012; Van Dyk, 2014). Scalability issues can cause an increase in the number of users, implying a huge problem in a medical centre (Kalid et al., 2018; Omar H Salman et al., 2014).

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In a large number of critically ill or injured patients, patients' prioritisation, which needs to be measured or evaluated, is an important yet difficult task (Alemdar & Ersoy, 2010; Azeredo, Guedes, Rebelo de Almeida, Chianca, & Martins, 2015). Patients' prioritisation employs medical conditions and the chance of survival, thereby indicating the chief problem (Ashour & Okudan, 2010; D Claudio & Okudan, 2010; Göransson, Ehnfors, Fonteyn, & Ehrenberg, 2008; Seising & Tabacchi, 2013). Prioritisations become complicated when patients are residing far from the hospital and use telemedicine; hence, triage nurses and physicians are not physically available to help such patients. This circumstance is more complex in telemedicine than in actual ED situations (O. H. Salman et al., 2014).

In the existing prioritisation studies, patients who are physically present at the ED of a hospital are prioritised by triage nurses and relied on the prioritising skills of nurses (Azeredo et al., 2015). Ideally, patients in an ED would be provided with care on an FCFS basis (D Claudio & Okudan, 2010). However, in reality, FCFS cannot be applied; hence, a quick, well-informed and timely decision on prioritising the patients is needed (D Claudio & Okudan, 2010; Tan, Tan, & Kauffman, 2013). Moreover, the proposed prioritisation solution in the previous studies (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018; O. H. Salman et al., 2014) can only address prioritisation in patients with single chronic disease; such approach cannot determine the emergency degree of each chronic disease in patients with MCDs to perform accurate prioritisation. However, no studies exist that can present a solution for remote prioritisation of patients with MCDs in a large scale, especially in the medical

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centre server of telemedicine applications (Tier 3). Such issue, if handled and addressed well, can save lives, among other advantages.

Furthermore, the prioritisation process for patients with MCDs requires decision making (DM) for each disease (i.e. CHD, high BP and low BP). This issue is considered as a specific problem of this research, considering that each patient should have a multigroup triage of different diseases for evaluating their emergency cases. This issue can be extended from a different side; decision makers (doctors) may give different weights for the mentioned diseases and multisource for each disease, thereby increasing the complexity of the task. Moreover, multigroup triage levels vary in each patient according to emergency cases. For instance, data variation of multigroup triage for each patient occurs when patient A has a risk level for heart disease, urgent level for high BP and normal level for low BP; meanwhile, patient B has an urgent level for heart disease, normal level for high BP and risk level for low BP. Hence, patient prioritisation is indeed a difficult task. Patient A can be prioritised at the highest level on the basis of heart disease (first disease). In contrast, patient B can also be prioritised at the highest level on the basis of low BP (third disease). In such case, a confusing question arises, that is, which patient will be prioritised first? Therefore, the prioritisation procedure that targets to assign a priority for a patient with MCDs includes simultaneous consideration of the emergency cases from MCDs. Thus, the prioritisation process of patients with MCDs involves multiple complex decision-making problems that represent an emergency degree in each chronic disease of these patients. Hence, a multiple-criteria decision analysis (MCDA) as the main concept to deal with this complicated situation is necessary.

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Based on the academic literature of MCDM techniques, the benefit of ranking approaches is appropriate for situations with many alternatives and attributes (Jumaah et al., 2017; Rahmatullah, Zaidan, Mohamed, & Sali, 2017; Zaidan et al., 2019). These methods have the capability to find the best alternative rapidly, and these techniques are considered the best among others. The mentioned methods are also specifically convenient to use when quantitative or objective data are given. These methods are functionally related to discrete-alternative problems. However, the major drawbacks of these ranking approaches include the lack of provision to weight elicitation and the consistency of judgments. In order to avoid this limitations, the literature review studies used external weighting techniques to improve the performance of the original ranking approaches through producing the importance of several criteria with respect to the objective; weighting approaches provide such a procedure (Alsalem et al., 2018; A. A. Zaidan et al., 2018). Furthermore, the benefit of other weighting techniques in both subjective and objective approaches can provide different weights for the adopted criteria to increase the performance of the DM process effectively. However, these techniques cannot be used to rank the available alternative individually. The explanation above applies to all MCDM techniques, except AHP. As shown in the literature, AHP technique was used for two directions, ranking and weighting purposes (O. S. Albahri, Albahri, et al., 2019). AHP was utilised to provide weights for criteria according to the preferences of experts and is remarkably restricted by the capacity of humans for processing information. However, AHP has an incredible drawback if used in the ranking purpose, which is inconvenient to use when dynamic data are provided in the DM process. This method is only used

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when static data are provided in the decision matrix. However, all existing ranking techniques, including AHP, cannot determine and break the decision into sub-decisions to guarantee the accuracy of the prioritisation process and determine the accurate emergency degree for patients with MCDs that represents multiple-DM problem (Mohammed et al., 2019), which is considered a technical gap. Although VIKOR technique produces balance between the overall utility and minimises the regret level (A. S. Albahri, Zaidan, Albahri, Zaidan, & Alsalem, 2018), assigning high priority for patient *n* more than patient *m*, in case of patient *n* is more risky when compared to patient *m*. These concerns, which are directly related to patients' lives, are our research problems. The problem statement configuration is illustrated in Figure 1.1.

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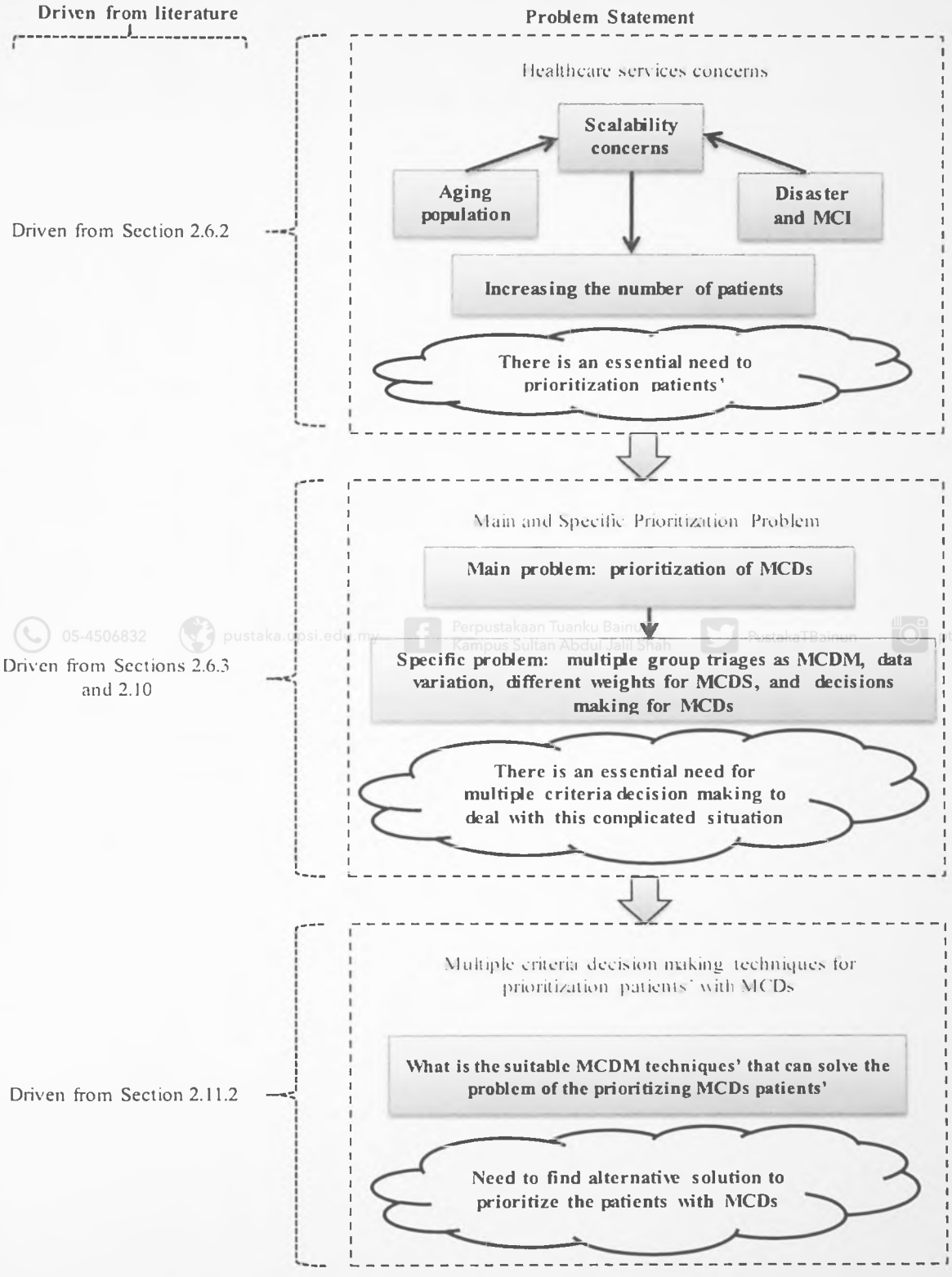


Figure 1.1. Problem Statement Configurations

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1.4 Research Qustiones

The following research questions have been framed to set the directions for this research:

1- What are the available technologies for patient prioritisation?
2- What are the requirements needed to construct a prioritisation technique for patients with MCDs in the telemedicine environment?
3- What is the suitable technique that can solve the problem of prioritising patients with MCDs in telemedicine?
4- Can the existing MCDM techniques be used to prioritise patients with MCDs?
5- How can patients with MCDs be prioritised on the basis of the proposed decision technique?
6- Is the proposed prioritisation technique for such patients valid systematically?
7- Is the performance of the proposed patient prioritisation technique better than those of other related techniques?

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1.5 Research Objectives

The objectives of this research are listed as follows:

1- To investigate the existing technologies of patient prioritisation in telemedicine applications and highlight their weaknesses.
2- To propose a new decision technique that deals with multiple decision-making for patients with MCDs.
3- To prioritise patients with MCDs on the basis of the proposed decision technique.
4- To validate and evaluate the proposed prioritisation of MCDs.

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1.6 Connections among Research Objectives, and Research Questions

In this section, all research questions can be answered through the research objectives. Each objective is linked to one or two questions. Table 1.1 below presents the connection among research objectives and the research questions.

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Table 1.1

Connection amongst Research Objectives and Research Questions

Research objectives	Research questions
1. To investigate the existing technologies of patient prioritisation in telemedicine applications and highlight their weaknesses.	1. What are the available technologies for patient prioritisation? 2. What are the requirements needed to construct a prioritisation technique for patients with MCDs in the telemedicine environment?
2. To propose a new decision technique that deals with multiple decision-making for patients with MCDs.	3. What is the suitable technique that can solve the problem of prioritising patients with MCDs in telemedicine? 4. Can the existing MCDM techniques be used to prioritise patients with MCDs?
3. To prioritise patients with MCDs on the basis of the proposed decision technique.	4. How can patients with MCDs be prioritised on the basis of the proposed decision technique?
5. To validate and evaluate the proposed prioritisation of MCDs.	5. Is the proposed patient prioritisation technique valid systematically? 6. Is the performance of the proposed patient prioritisation technique better than those of other techniques?

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As shown in Table 1.1, the first objective corresponds to the first and second question, the second objective corresponds to the third and fourth question, the third objective corresponds to the fifth question, and the last objective corresponds to the sixth and seventh question.

1.7 Research Scope

This research is a cross domain involving healthcare services and expert system algorithms. It is designed to solve the problem of remote patients' prioritisation for telemedicine environment. Different research methods are involved in the study

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because the problem is classified to be multidisciplinary. In this study, MCDs are involved in the experiments; thus, the settings and parameters of the multigroup triage used in the prioritisation process are adjusted.

The secondary dataset of 500 patients from the most relevant study in the remote prioritisation area is adopted (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018). This dataset contains three diseases (i.e. CHD, high BP and low BP), which are presented in two parts. The first part is the CHD. Sensors (e.g. electrocardiogram [ECG], oxygen saturation [SPO2] and BP) and texts were used as patients' vital signs to be assessed by healthcare providers. The second part includes the high and low BP diseases, which consist of sensors for systolic and diastolic pressures to be used as patients' vital signs for the healthcare providers to assess simultaneously with the first dataset (CHD).

The outcomes of the research indicate the research type. The output of this study is a new decision technique that can be used to improve the process of prioritising patients with MCDs for telemedicine.

Furthermore, the proposed technique for reorganising of opinion order to interval levels (TROOIL) represents the improvements in the performance of telemedicine applications from the perspective of MCDs. The general scheme for our research, as well as the research method, research type and research domain is presented in Figure 1.2.

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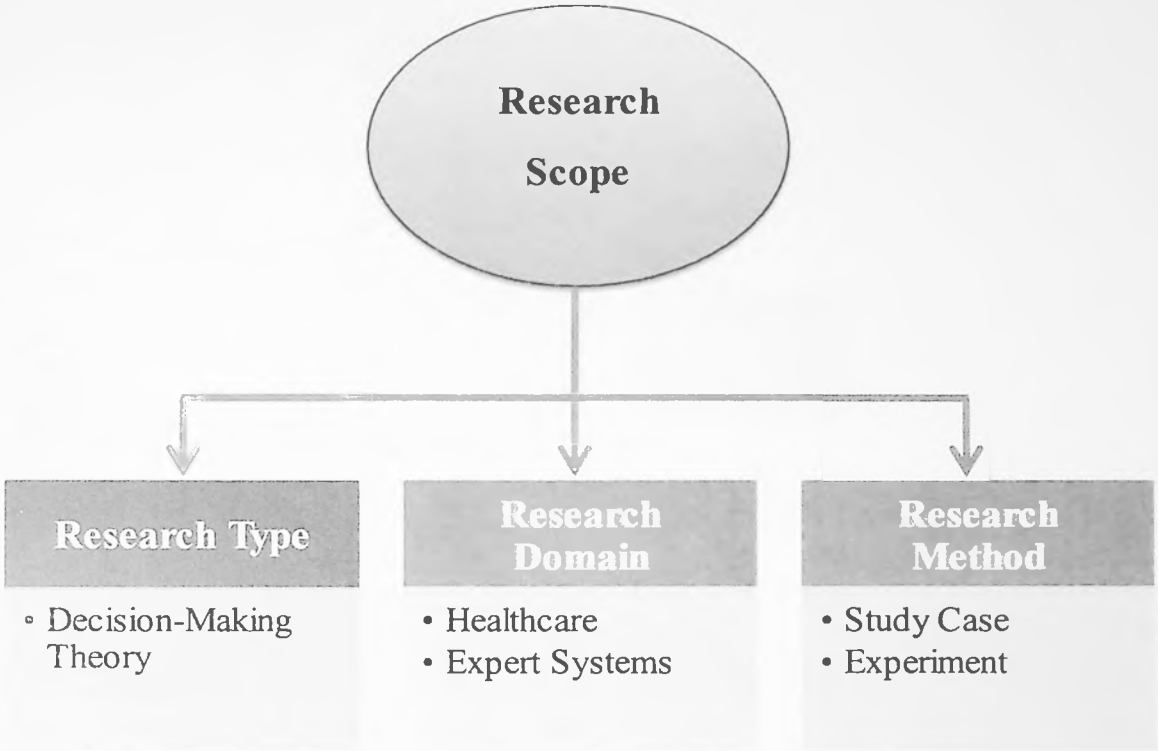


Figure 1.1. General Scheme and Scope of the Study

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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 organized into three categories according to related benefits. The corresponding significant is presented for further discussion (Figure 1.3).

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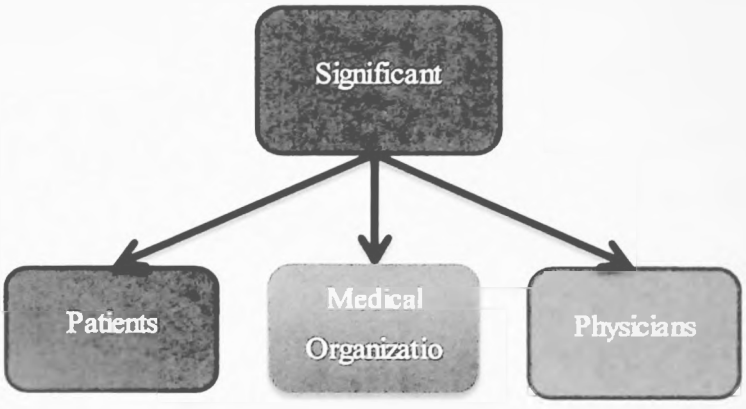


Figure 1.2. Significant Categories of the Study

1.8.1 Benefits to Patients

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EDs in hospitals are places where numerous people must be attended immediately and where critical situations are expected to emerge. When a patient arrives at the ED, he/she needs to be classified according to the seriousness of their conditions. A healthcare application remotely recognises patients with the most acute emergency cases; the patient with the most acute emergency case is the first to obtain a response from the server (Ganapathy, Vaidehi, Kannan, & Murugan, 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 on elderly and persons with disabilities, and provide the patients with a service-oriented emergency response when they suffer abnormal health conditions (Hussain, Wenbi, da Silva, Nadher, & Mudhish, 2015; Peleg et al., 2017). Telemedicine services can effectively improve the quality of healthcare in large centres and deliver these

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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 ensures continuous healthcare services to patients with MCDs by patient prioritisation among hospitals in cases of natural disasters or involving 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 adequately meet the requirements of patients (A. S. Albahri et al., 2018). Moreover, this research provides a way to improve the priority setting processes for healthcare providers who constantly make difficult resource decisions.

1.8.3 Benefits to Physicians

In a MCIs, 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 patients' status (Beck & Georgiou, 2016; Besaleva

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& 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 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). Furthermore, tele-expertise can assist medical teams to gain real-time information of MCDs to perform a timely and accurate treatment of their patients, as can be demonstrated in this current research. Thus, this study is also essential for physicians.

1.9 Research Organisation

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

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Chapter 1 provides the research background and research problem. Moreover, this chapter demonstrates the research questions, objectives and the connection among research objectives and the research questions. This chapter also presents the research scope and significance of the study.

Chapter 2 presents a systematic review protocol for the area of telemedicine applications, followed by an overview of the following: sensor based (Tier 1), gateway based (Tier 2) and server based (Tier 3). MCDs in remote healthcare monitoring (RHM) were also reviewed, followed by the main medical sensors and sources involved in monitoring common chronic diseases. This chapter also examines and reviewed triage systems, standards and guidelines. Furthermore, the prioritisation process is addressed. This chapter ends with technical analyses to the research problems and highlights what should be accomplished to solve such problems.

Chapter 3 provides the full description of the research methodology, which consists of four phases, namely, preliminary study, decision technique, and prioritisation of patients with MCDs, validation and evaluation. Each phase corresponds and addresses to one research objective.

Chapter 4 presents the results based on the proposed work in several sections. Each section has its own aims. These sections show the result of the dataset of patients with MCDs; in this dataset, three diseases are used as input data in the proposed work.

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Chapter 5 presents the validation and evaluation results of the proposed work. In this chapter, several steps are involved in the validation and evaluation processes of the performance in patient prioritisation for telemedicine to overcome the research problems.

Chapter 6 presents the attained research goals, 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 prioritisation process involving patients with MCDs and the remote monitoring over telemedicine. In the statement of the problem, the prioritisation process of such patients involves complex multiple-decision-making problems that represent the emergency degree of each chronic disease for each patient. This research mainly aims to improve the patient prioritisation; 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. Furthermore, this chapter presents the research benefits and significance, which are organised into three categories according to related benefits. The final part of this chapter presents the general idea of the other chapters in this thesis.

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CHAPTER 2

LITERATURE REVIEW

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2.1 Introduction

This chapter presents a detailed description of a literature review background for this research. In Section 2.2, a systematic review protocol of telemedicine application is presented, followed by an overview of the telemedicine application in Section 2.3. Section 2.4 discusses the sensor-based (Tier 1) telemedicine application, Section 2.5 discusses the gateway-based (Tier 2) telemedicine application, and Section 2.6 discusses the server-based (Tier 3) telemedicine application. Moreover, MCDS in RHM are presented in Section 2.7. This chapter also examines the main medical sensors and sources involved in the monitoring studies of common MCDs, as discussed in Section 2.8.

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In Section 2.9, triage system standards and guidelines are discussed. Besides, concern for prioritisation process is presented in Section 2.10. In addition, the definitions, advantages, challenges, techniques and the application of MCDM in healthcare domain are discussed in Section 2.11. Furthermore, the chapter summary is presented in Section 2.12, whereas the literature review structure for this chapter is illustrated in Figure 2.1; the details are explained throughout this chapter.

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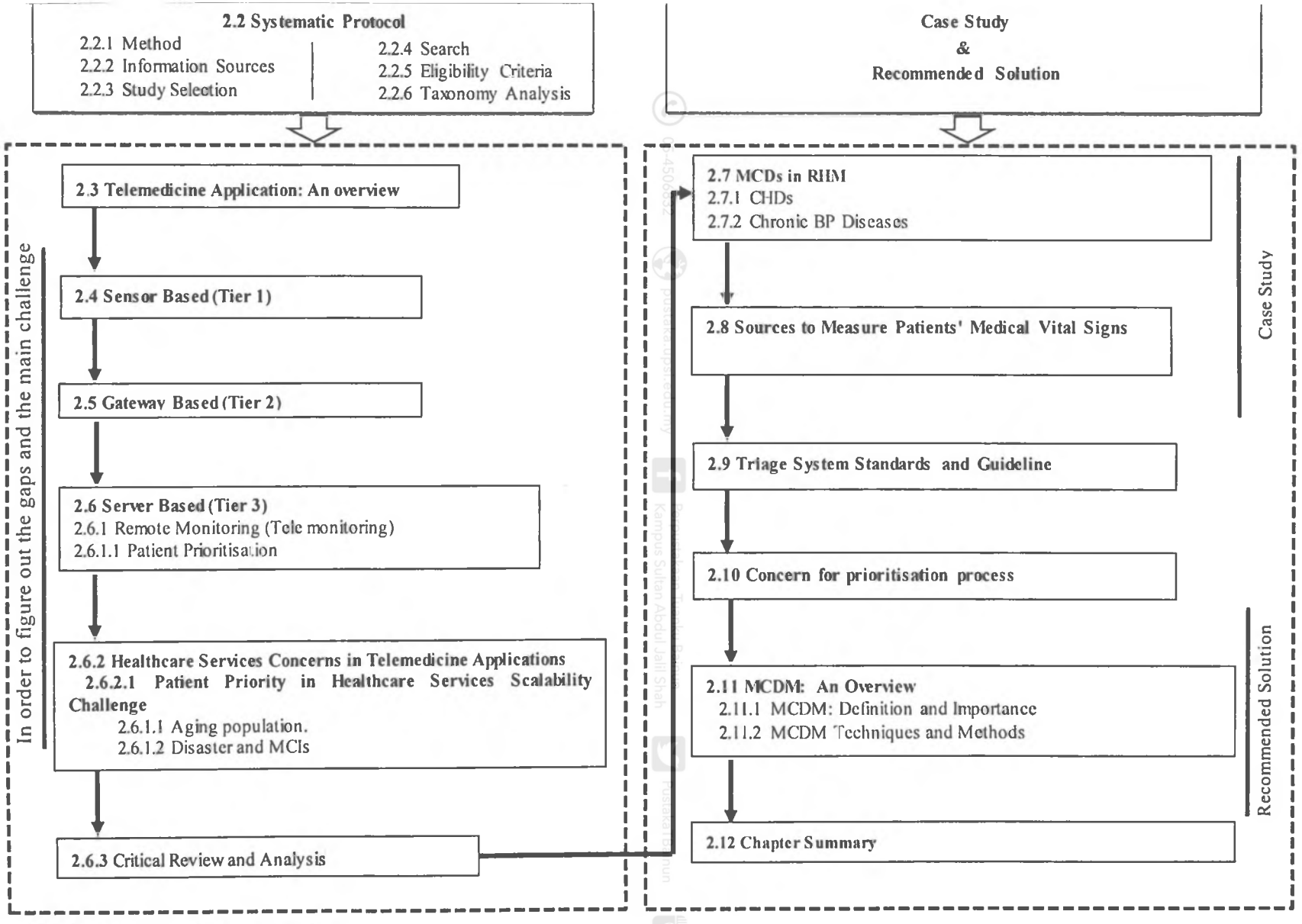


Figure 2.1. Literature Review Structure

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2.2 Systematic Review Protocol

In this section, the systematic review protocol that has been used in this research is presented. The systematic review method, information sources, study selection, search and the eligibility criteria are described in the following subsections.

2.2.1 Method

The scope of this study is covered by the most important keywords such as 'telemedicine', 'triage', 'priority' and 'sensor'. It excludes any other telemedicine studies, such as survey and reviews. In addition, the scope is limited to the English literature but considers all health-related areas.

2.2.2 Information Sources

Three digital databases have been selected to search for target articles: (1) the Science Direct database offering access to science, technology and articles in highly reliable journals; (2) the IEEE Xplore Library of technical literature in engineering and technology and (3) the Web of Science (WoS) service. These databases index cross-disciplinary research in sciences, social sciences, arts and humanities. The justification behind this selection is to cover the scientific and technical literature and

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to provide an extensive insight into researchers' efforts in a wide yet relevant range of disciplines.

2.2.3 Study Selection

Study selection consists of searching the literature sources, followed by three iterations of screening and filtering. The first iteration excludes the duplicate articles and collects only the articles from the last six years (2012–2017) by using the Mendeley software. The second iteration filters the reading titles and abstract and excludes articles out of our domain. Lastly, the third iteration filters a full-text reading and excludes articles out of our domain and out of our criteria, as shown in Figure 2.2. All iterations apply the same eligibility criteria, followed by screening and reviewing.

2.2.4 Search

The search was conducted in Science Direct, IEEE Xplore and WoS databases via their search boxes on January 2017. We used a combination of keywords that contained 'medical system'; 'Telemonitoring'; 'E health'; 'Telemedicine'; 'Telehealth'; 'healthcare services'; 'remote monitoring'; 'mobile physician' in different variations, combined by the operators 'OR' and 'AND', followed by 'Triage'; and 'Priority' in different variations, combined by the operators 'OR' and 'AND', followed by 'sensor'. The exact query text is shown at the top of Figure 2.2.

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We further used the options in each search engine to exclude book chapters and other types of reports other than a journal and conference articles, considering that those two venues are the most probable to include up-to-date and proper scientific works relevant to our survey in this emergent trend of telemedicine.

2.2.5 Eligibility Criteria

Every article that met the criteria was included, as listed in Figure 2.2. We set an initial target of mapping the space of research in our title into a general and coarse-grained taxonomy composed of two categories. These categories were derived from a presurvey of the literature with no constraint (Google Scholar was used to obtain a preview of the landscape and directions in the literature). After the initial removal of duplicates, articles were excluded in three iterations of screening and filtering if they did not fulfil the eligibility criteria. Examples of exclusion reasons include the following: (1) the article is non-English, (2) the focus is on a specific aspect of healthcare technology, and (3) the target is the general telemedicine application. Herein, we focus on healthcare services, patient prioritisation, patient triage, disaster management, network failure, sensors in telemedicine and security of telemedicine.

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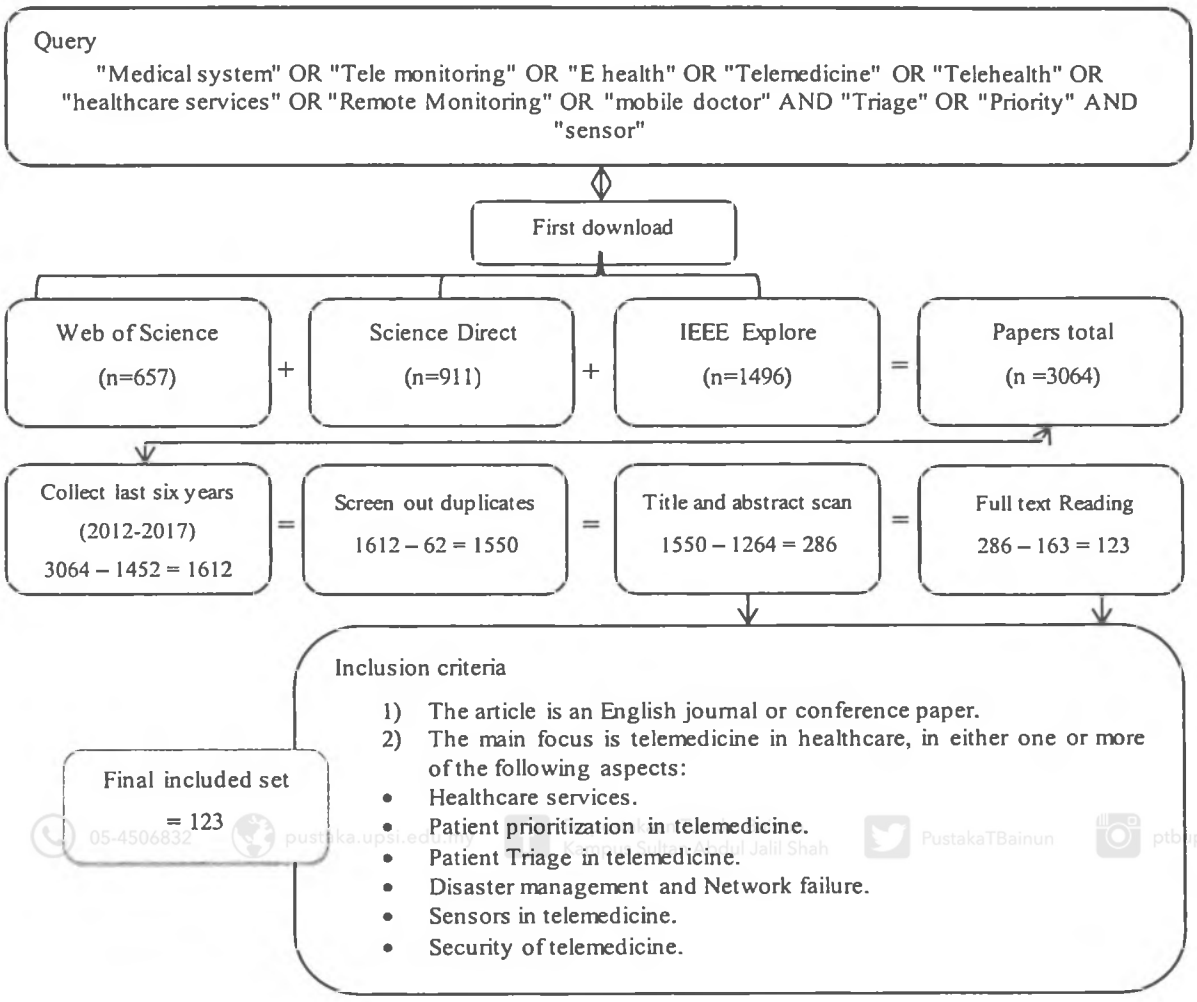


Figure 2.2. Study Selection Flowchart Containing the Exact Query and Inclusion Criteria

2.2.6 Taxonomy Analysis

The initial query search obtained 3064 articles (i.e. 911 from Science Direct, 1496 from IEEE Xplore and 657 articles from WoS) published within 2007 and 2017. Unfortunately, we could not download only two scientific articles from WoS because of accessibility issues. Filtered articles by the following sequence have been adopted

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in this research, with three categories. A total of 1612 papers were collected roughly from the last six years (2012–2017), and 62 papers were duplicate among three databases, ultimately acquiring 1550 papers. After scanning the titles and abstracts, 1264 more papers were excluded, resulting in only having 286 papers. The last full-text reading excluded 163 papers, leaving 123 papers in the final included set. These finally included papers were read thoroughly, aiming to determine a general map for the conducted research on this emerging topic.

As a result of the taxonomy analysis, specific patterns and general categories are observed in the telemedicine architecture. The mapping and domains of telemedicine technology are illustrated in Figure 2.3.

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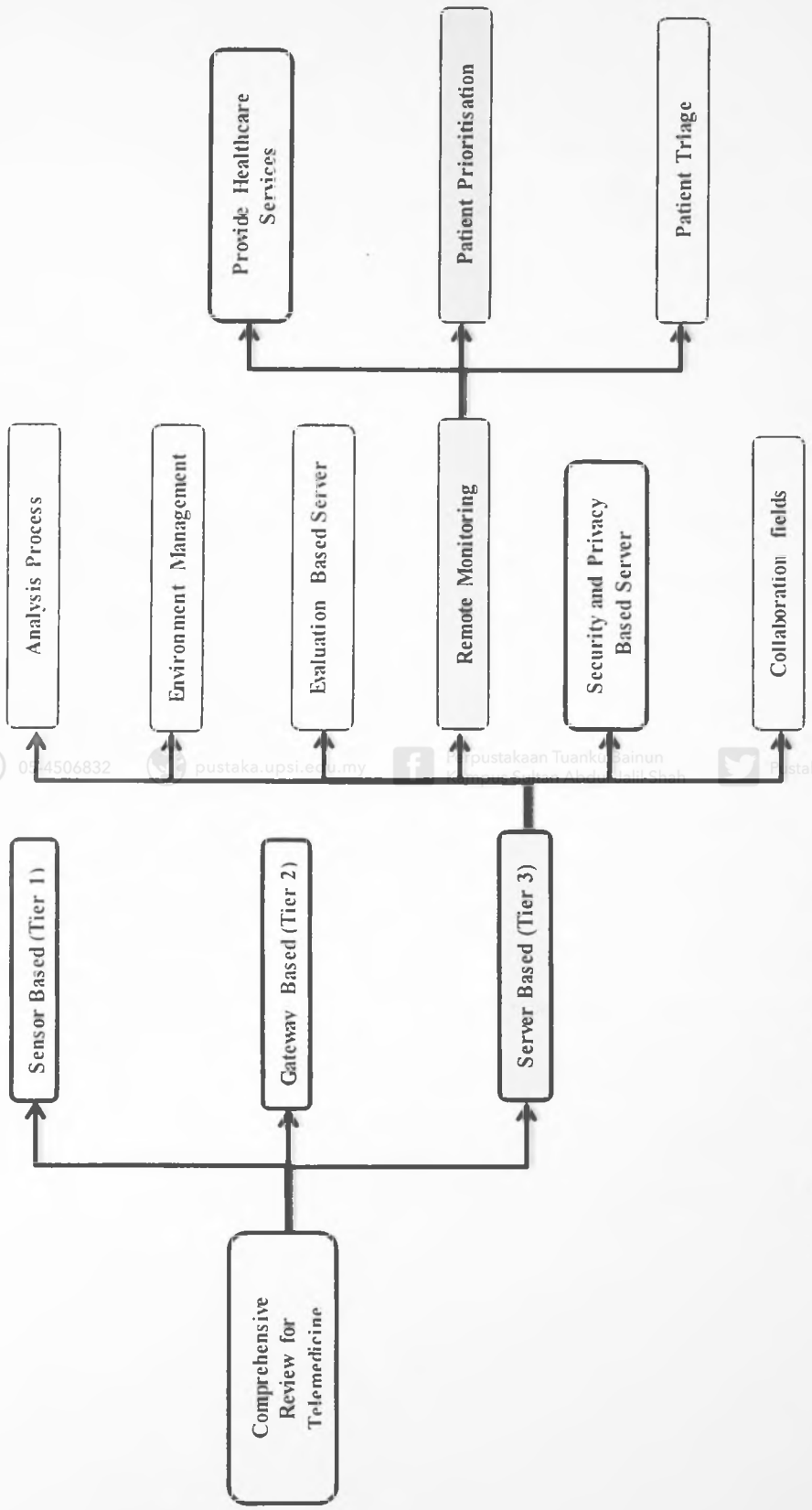


Figure 2.3. Research Taxonomy on Telemedicine Applications

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2.3 Telemedicine Applications: An overview

According to (Slotwiner et al., 2015), remote monitoring is defined as 'the automated transmission of data based on pre-alert related to device functionality, clinical events and clinical condition of patients'. Remote health-monitoring systems (RHMSs) in telemedicine generally transmit in real-time the patients' vital data from a remote location to physicians by using sophisticated communication and information technologies (Baig & Gholamhosseini, 2013). In healthcare, remote monitoring is useful and gains a huge benefit for frail patients, as well as housebound and elderly patients, considering that it is easy to use (Lemelin et al., 2008). Many strategies of remote monitoring have been suggested through involving interviews by phone or other advanced systems, such as remote access control via implantable devices for vital signs, which can be electronically transferred, and external and wearable hemodynamic monitors (Palozzi, Binci, & Appolloni, 2017). The system of disease management contain personal medical devices for health monitoring, such as sensing and data collection within a group of online services. These services include visualisation, data aggregation and analysis functions of physicians, aside from the alert functions that can warn urgent conditions that caregivers noticed in patient's telemetry. The current architecture of telemedicine contains three tiers (Mciver, Light, Chowdhury, Jr, & Light, 2012; O. H. Salman et al., 2014), as illustrated in Figure 2.4.

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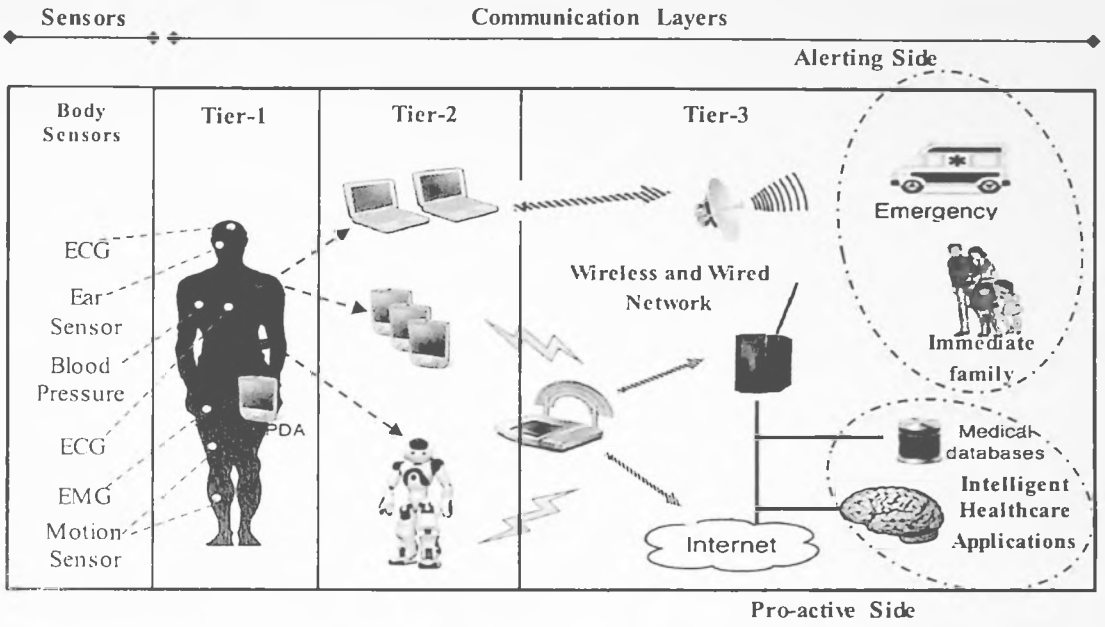


Figure 2.4. Three-Tiered Architecture of the Telemedicine system for Healthcare Monitoring

In the architecture of telemedicine, collecting the individual health vital signs is performed in Tier 1. The devices in Tier 1 include the 'interoperable medical devices' (IMDs), which measure a certain type of physiological indicators, such as ECG or SPO2. Each sensor that is attached to components that filter and amplify the collected data, sends the resulting measurements to Tier 2. Tier 2 gathers the data that are collected using the monitoring devices in Tier 1. Through this tier, data are also transmitted periodically to the remote server over an external gateway that supplies a wide range of communication. Tier 3 (server) is a remote computer used for monitoring the data in real-time by clinicians or a database for postprocessing. RHMS in telemedicine space is considered substantial and worthy in research field due to its relevance to human care. Enhancement can be achieved by various aspects, such as inserting a new hardware (sensor) and proposing algorithms and software that can

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improve the medical services and process the data effectively (O. H. Salman et al., 2014).

Emerging technologies of healthcare might change the way of providing healthcare in developing countries; these technologies can help in handling serious medical challenges, such as prioritisation of patient and acquisition of vital signs of patients (Bagula et al., 2016; Mandava, Lubamba, Ismail, Bagula, & Bagula, 2016). In the literature on telemedicine application, three main categories are observed, as shown in Figure 2.3, namely, sensor based (Tier 1), gateway based (Tier 2) and server based (Tier 3). Further investigations regarding the telemedicine application in these categories are presented in the following sections.

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2.4 Sensor based (Tier 1): An Overview

This category highlights the challenges and sensor techniques which can provide continuous monitoring of healthcare services. Wireless body area networks (WBANs) include small-sized wireless sensors that collect and carry patient's vital sign information (Bradai, Charfi, Fourati, & Kamoun, 2016). In the literature, sensor-based (Tier 1) telemedicine applications have been discussed in seven domains.

The first domain is ontology, which focuses on the extended principles of topology that deeply explains wearable platforms containing 'mainstream magnetic and inertial measurement units' (Villalonga, Pomares, Rojas, & Banos, 2017).

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The second domain is reliability, which contains three areas in the literature. The first area is congestion control; some studies focus on detecting congestion and control protocols to remote health-monitored patients and their healthcare conditions by WBANs (Ghanavati, Abawajy, & Izadi, 2015, 2016). The congestion management protocol is the main contribution of other studies, and it is used in medical applications (Rezaee, Yaghmaee, & Rahmani, 2014; Rezaee, Yaghmaee, Rahmani, & Mohajerzadeh, 2014). The second area is packet delay and link quality. (Almadani, Saeed, & Alroubaiy, 2016) established the 'real-time publish-subscribed middleware functions' into the healthcare applications, whereas (David Claudio, Kremer, Bravo-Llerena, & Freivalds, 2014) scheme of decision and examine the techniques of multiple attribute decision analysis. Another study presented an architecture for healthcare system to deal with dynamic behaviour and various traffic in WBAN (Gambhir, 2016). Another study was focused on the scheme of health tracking and the structure of sensor with simulated results (Zhao & Kerkhoff, 2014). Another study attempted to enhance the quality of Telehealth system through proposing an infrastructure (Shah, Kim, Khadra, Feng, & Fellow, 2014). Meanwhile, the third area is electromagnetic interference (EMI); herein, the number of users is reduced through keeping EMI on medical sensors at a satisfactory level (D. Lin et al., 2016).

The third domain is energy efficiency. Some studies were focused on 'higher energy efficiency and robust data transmission' by reducing energy consumption and spread the network lifetime by increasing the predictability of a system (Bradai et al., 2016; Hu et al., 2015; Iftikhar & Ahmad, 2014; Iftikhar, Elaiwi, & Aksoy, 2014;

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Sevin, Bayilmis, & Kirbas, 2016). The last study introduced green-cloud-assisted healthcare services on WBANs (Chiang, Lai, & Huang, 2014).

The fourth domain is the quality of service (QoS). Some studies presented QoS for WBANs, which supply parameters to understand the QoS-performance criterion (Bradai et al., 2016; Hu et al., 2015; Iftikhar & Ahmad, 2014; Iftikhar et al., 2014; Sevin et al., 2016).

The fifth domain is security and privacy. One of the studies focused on securing wireless communication for sensor nodes and implemented a prototype application for biomedical sensors (Baehr, Mckinney, Quirk, & Harfoush, 2014). Another article presented a secure logging for the information collected from the WSN nodes (De, Braeken, Touhafi, & Wouters, 2013). Moreover, another study introduced various security levels in BANs for medical devices to prevent long-distance attacks (Hedin et al., 2014). Another study provided cryptographic hash algorithm to preserve data integrity (Soufiene, Bahattab, Trad, & Youssef, 2016). Lastly, a study presented an integration of healthcare enterprise to various eHealth/mHealth systems (Rubio, Trigo, Alesanco, Serrano, & García, 2016).

The sixth domain is evaluation and assessment. One of the studies focused on the performance evaluation of the IEEE standard 802.15.6 (Benmansour, Ahmed, & Moussaoui, 2016; Fourati, Idoudi, Val, Bossche, & Saidane, 2015). Another study evaluated the efficiency of wearable health devices to enhance the communication among healthcare units (Radhakrishnan, Duvvuru, & Kamarthi, 2014). Meanwhile, a

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study introduced an evaluation of miniature wireless vital-sign monitor for potential trauma triage in intensive care units (Meizoso et al., 2017).

The seventh domain is prioritisation over the sensor. Some studies presented priority-based time-slot allocation scheme for WBANs to achieve energy efficiency (Misra & Sarkar, 2015; Puri, 2015; Ru Kong, Chen, Yu, Yang, & Guan, 2013). Another study proposed a priority for healthcare applications based on the integrated 'cross-layer routing protocol' and 'cross-layer medium-access channel protocol' (Ben et al., 2015). Another study proposed two new scheduling algorithms to satisfy QoS requirements in WBAN networks and to overcome the starvation mode of the packets without the highest priority (Bradai, Fourati, & Kamoun, 2015). Another article used 'non-pre-emptive priority queue discipline' to present a new traffic-sensitive WBAN (Gündoğdu & Çalhan, 2016). Another study presented priority based on 'congestion-avoidance hybrid scheme' for WSN to provide efficient mechanism to reduce the power consumption (Kaur & Scholar, 2015). Furthermore, a study proposed the medium-access control (MAC) protocol for considering the priorities of several biosignals with different characteristics and setting up minimum packet delay time to guarantee data effectiveness (R. H. Kim & Kim, 2015). Other studies focused on performance improvement of the 'MAC protocol of WBANs' in prioritising numerous vital signs to ensure data efficiency (Ahmed & Mamoon, 2015; Rezvani & Ghorashi, 2013). Finally, (Ren, Wu, Li, Pirozmand, & Obaidat, 2015) presented probabilistic real-time systems in BASNs with fixed-priority pre-emptive scheduling.

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2.5 Gateway based (Tier 2): An Overview

Gateway is a common literature term that refers to using any wireless devices, such as phones and other devices for communication, which are often used for educating consumers regarding the use of 'preventive healthcare services' in medical care. Gateway-based (Tier 2) telemedicine applications have been studied in different domains.

The first domain is a mobile user interface (MUI). the study of (Alnanih, Ormandjieva, & Radhakrishnan, 2013), the approach depends on a context and rules to design MUIs for mHealth use.

The second domain is evaluation. The study of (Fratini & Caleffi, 2014) focused on evaluating the medical alarm dissemination feasibility by using mobile phones in failure or congestion cases of network in an urban environment.

The third domain is treatment support and disease surveillance. The key purpose of both topics is to decrease the harm caused by the outbreak, epidemic, predicted and pandemic cases, then observe and further identify the factors causing such situations. Some articles conducted a study to allow patients to monitor and manage chronic diseases, whereas some conducted a study about chronic-disease management and patient monitoring on body temperature, heart rate and blood pressure (Boursalie, Samavi, & Doyle, 2015; Fezari, Rasras, & Emary, 2015). Moreover, some studies introduce applications that could be used for some other

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diseases, such as fever, high BP and diabetes, by devices based on biometrics, such as tensiometers, thermometers and glucometers (Sebillo et al., 2015; Villarreal, Fontecha, Hervas, & Bravo, 2014). Other studies presented systems based on social media, such as the study of (Katib, Rao, Rao, Williams, & Grant, 2015), which presented the tracking of children's vaccination coverage in rural areas based on a software. In addition, (Lwin et al., 2014) developed a software for dengue prevention in Sri Lanka. Patients with major depression were treated by a method presented in (Bresó, Martínez-Miranda, Fuster-García, & García-Gómez, 2016). This method allows such patients to obtain daily interactive sessions featuring personalised and adaptive, as well as continuous monitoring of patients who have Parkinson's disease (Chakraborty, Ghosh, Jamthe, & Agrawala, 2013). The study of (Hermens, op den Akker, Tabak, Wijsman, & Vollenbroek, 2014) presented systems for personal coaching, which included a combination of 'on-body sensing with smart reasoning and context-aware feedback'. Lastly, eating-disorder treatment was studied by (Piotin, Benassarou, Blanchard, Nocent, & Bertin, 2013).

The fourth domain is disaster management. Management and organisation of all the responsibilities and resources necessary for addressing emergency cases cover all the humanitarian aspects, that is, recovery, preparedness and response, to be able to decrease the harmful effects of natural disasters, indicating the system of mHealth management. These studies applied the system of mHealth in a 'tsunami-stricken disaster' scenario, as well as proposed a platform for developing 'a field accident and emergency centre intelligent monitoring system' (Adibi, 2015; Beck & Georgiou, 2016). The study of (Besaleva & Weaver, 2013) presented an assessment system of

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patients in real-time based on 'mobile electronic triaging' and has been performed by sensor-detected information and crowdsourcing. Other systems for rescue operations in urban areas are based on a situational awareness, both indoor and outdoor (Ganz et al., 2015). Tracking system of pilgrims in the holy spaces was also developed (Gunasekaran & Suresh, 2014). The study of (Renner et al., 2014) presents a network called 'Medical Body Area Network'; in case of a disaster, this network gathers the triage and general physiological data by using sensors.

The fifth domain includes the integration of data source and aggregation. Integration refers to the incorporation of multiple sources of data that can be heterogeneous to utilise healthcare data in the clinical field and produce a mobile operator to develop solutions that support the connection between patients and healthcare providers. Meanwhile, aggregation is demonstrated in 'Mobile Aggregation Centres', thereby growing the system scalability and flexibility. Modelling of linear data with an expert priority was presented by (Ali et al., 2015). The theory-based approach and the design description among architecture, algorithmic and technology systems were reported by (Gaynor & Waterman, 2016). Healthcare environments in virtual organisations were integrated by (H.-K. Kim, 2014). Two architectures for the aggregation of healthcare data were firstly presented by (Misra & Chatterjee, 2014) through cloud-assisted WBAN, whereas the second, that is, a priority scheme for cloud-assisted WBANs with privacy maintenance was presented by (Zhang, Liang, Baura, Lu, & Shen, 2014).

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The sixth domain is network management. In network management, any wireless technologies, such as mobile phones, are used to support the objectives of mobile health through using SMS, calling and mobile-phone applications, as well as to develop and enhance the management of mobile healthcare network. The scheme of allocating the resource of radio using capacity sharing scheme depends on a priority-aware pricing proposed by (Yi, Zhao, Cai, Lobato de Faria, & (Michael) Zhang, 2016). In other study, (Yi, Alfa, & Cai, 2016) proposed a mechanism of incentive compatibility in e-health networks to schedule the transmission. Scheme supports multi-user sharing proposed by (Zhang Yi et al., 2015). Another study presents patient monitoring using mobile ad-hoc network to classify challenges to improve the communication reliability (Sneha & Varshney, 2013).

'Ambient Assisted Living (AAL)' is the seventh domain. This domain focuses on patient tracking and monitoring, particularly in patients staying alone at home or solely receiving treatment in hospitals. Models that simulate daily activities of a person living alone at home were proposed by (Bouakaz et al., 2014) , the study of (De Backere, Bonte, Verstichel, Ongenae, & De Turck, 2017) , as well as (Kormanyos & Pataki, 2013), for the implementation of data-driven, cloud-based and semantic software through the knowledge acquired by such models. 'Internet-of-Things (IoT)' and 'Cyber-physical Systems' are more capable of predicting and cleverer for home/office in daily life and for hospitals, as presented by (Rahmani et al., 2018).

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The eighth domain is the decision support system which is a computerised system that assists in decision-making processes to provide precise diagnosis for any diseases. Decisions related to context awareness sets and processing are enhanced, improving the presentation of information to professional healthcare (Varshney, 2014), and builds DSSs based on knowledge embeddable in mobile devices proposed by (Minutolo, Esposito, & De Pietro, 2015). Meanwhile, another study focused on discovering and decreasing false alarms produced by the monitoring sensors of patients (Ahsanul & Mahfuzul, 2013).

2.6 Server based (Tier 3): An Overview

This category is responsible for the real-time remote monitoring of patients through using a remote computer in telemedicine environment. In the telemedicine server, the vital signs of patients are collected and then sent to the server for further analysis and investigation. After analysing the vital signs, the medical server can support the medical professional by identifying the appropriate healthcare services for patients remotely (O. H. Salman et al., 2014). In the literature, server-based telemedicine applications have been studied in different domains.

The first domain is the analysis process. Some studies presented a huge data analysis for sensing techniques that improved the efficiency of healthcare services (Pombo, Garcia, Felizardo, & Bousson, 2014; Sakr & Elgammal, 2016). Meanwhile,

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(Moutacalli, Marmen, Bouzouane, & Bouchard, 2013) presented an analysis of the 'activity pattern mining'.

The second domain is the environment management. Some studies focused on managing the data collection process of elderly people within hospitals (Bharatula & Meenakshi, 2016; Vaidehi et al., 2013). Furthermore, another study focused on helping physicians to improve the management and reveal the issue of overcrowding (Ben Othman et al., 2016).

The third domain is the evaluation and assessment. Some studies evaluated the features and effectiveness of common telehealthcare systems (Peleg et al., 2017; Tamura et al., 2014; Tawfik & Anya, 2015).

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The fourth domain is the security and privacy. The vital signs collected from medical sensor networks were secured through ensuring confidentiality and integrity (Lounis, Hadjidj, Bouabdallah, & Challal, 2016). Another study focused on securing the e-Healthcare society through proposing various actors to communicate securely (Saleem, Derhab, Al-Muhtadi, & Shahzad, 2015).

The fifth domain is the collaboration fields, which are divided into two areas: cooperative environment, and tele-expertise between professionals. The first area, that is, cooperative environment, involves ubiquitous healthcare to share and exchange medical data over local area networks. A study (J. Wang, Qiu, & Guo, 2017) focused on decentralised data to access on EHRs and PHRs with high performance; these data

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were saved in distributed data centres. Another study enhanced the healthcare information system to provide high-quality information at any time and any place (Nageba, Rubel, & Fayn, 2013). The second area, that is, tele-expertise between professionals, focused on exchanging the experience between physicians or professionals to share knowledge and formulate proper decisions for diagnosis and treatment (M. B. Doumbouya et al., 2015; Mamadou Bilo Doumbouya et al., 2014; Sene, Kamsu-Foguem, & Rumeau, 2015; Tegegne & (Theo) van der Weide, 2014; Urovi et al., 2017).

Finally, the sixth domain is the remote monitoring (telemonitoring). Further investigations regarding this domain are presented in the following subsection.

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2.6.1 Remote Monitring (Telemonitoring)

In remote monitoring, the medical professional monitors the emergency cases of patients remotely, as well as providing real-time data analysis and allowing the provision of instant feedback to the patient (M. B. Doumbouya et al., 2015; O. H. Salman et al., 2014). The domain of remote monitoring includes studies that are categorised in three areas: patient triage, provision of services to the patient, and patient prioritisation.

The first area is patient triage, which means categorising patients on the basis of their emergency cases. Some studies focused on inside ED triage, which is

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discussed by (Moreno et al., 2016; Niswar et al., 2013; Santos et al., 2015), whereas other studies focused on outside ED triage, which is discussed by (Niswar et al., 2015; Paulus et al., 2016; Rodriguez et al., 2014; Ullah et al., 2013).

The second area contributes on remote healthcare service provision. Several studies have focused on an alert emergency service that alarms the caregiver to provide fast response in case when vital signs become irregular (Gómez, Oviedo, & Zhuma, 2016; Hussain et al., 2015; Lamprinakos et al., 2015; Mendes et al., 2014; Sung & Chang, 2014; Zanjal & Talmale, 2016). Many studies provided services such as suggestions, tips, drug prescriptions, recommendations and telehealth consultation (AHMED et al., 2014; Ganapathy et al., 2013; Miah, Hasan, & Gammack, 2017; Moore, Thomas, Qassem, Bessis, & Hu, 2015; Traverso et al., 2015). Some studies recommended on choosing nearby and suitable hospitals/physicians according to the patient's conditions (Kovalchuk, Krotov, Smirnov, Nasonov, & Yakovlev, 2018; Rajkumar & Sriman Narayana Iyengar, 2013). A study focused on providing healthcare services and treatment while travelling among vehicles on-the-fly (Kumar, Kaur, Jindal, & Rodrigues, 2015). Another study presented the existence of first-aid services in an ambulance (Moretti, Cicalò, Mazzotti, Tralli, & Chiani, 2014). Moreover, another study introduced a new eldercare service that connects the clinic of a remote physical therapist and the home of an elderly (Calyam et al., 2016). Finally, (Teijeiro, Félix, Presedo, & Zamarrón, 2013) presented an approach for managing the prescribed medication for patients by notifying on drugs and doses.

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The third area is the patient prioritisation. Further investigations regarding patient prioritisation of the server-based (Tier 3) telemedicine application as the focus of this study are presented in the following subsection.

2.6.1.1 Patient Prioritisation

This section addresses patient prioritisation of the server-based (Tier 3) telemedicine application, indicating that the prioritisation of patients should be appropriately arranged to determine the necessary treatment and to transport them to hospitals according to the patients' condition. In the literature, telemedicine application has been studying on patient prioritisation. This study mainly focused on remote monitoring of patients, as well as on the proposed application based on android using IoT. This application includes two stages: Firstly, vital signs are gathered from various sensors, and then it categorises patient status. Secondly, the application sends the gathered vital signs through LTEFemto Cell networks to centres of healthcare for patient prioritisation (Hindia et al., 2016). Another research attempted on developing a system based on optimisation using multiswarm PSO technique to handle some healthcare issues, such as delivering of services for numerous patients, difficulty to store large data because of unavailability of servers, and data requests are not categorised and enhanced by patient prioritisation (Ganapathy et al., 2014). Another research utilised 'MSHA' to present a system of telemonitoring based on integration sensory sources (BP, ECG and SpO2) and nonsensory source (text inputs). The research tried to enhance the efficiency of healthcare scalability by assisting remote

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prioritising and triaging heart chronic diseases of patients (O. H. Salman et al., 2014). Lastly, another study (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018) proposed a methodology to enhance the decision-making in prioritising of patients with CHD over the telemedicine.

2.6.2 Healthcare Service Concerns in Telemedicine

This section introduces an overview of healthcare service challenges in telemedicine. Further healthcare services are apparently required, particularly the services supplied from outside of the hospitals (Topaz, 2014). Among others, chronic diseases (e.g. cardiovascular diseases, cancer and diabetes) are critical matters for healthcare services, given that these diseases embody one of the first causes of mortality, morbidity and disability (World Health Assembly, 2013). Several challenges occur in healthcare service provision for telemonitoring systems (Rocha, Martins, Freire, et al., 2013; O. H. Salman et al., 2014). However, this study focused on the challenges related to scalability. The challenges of healthcare service in relation to scalability problem are presented in taxonomy shown in Figure 2.5.

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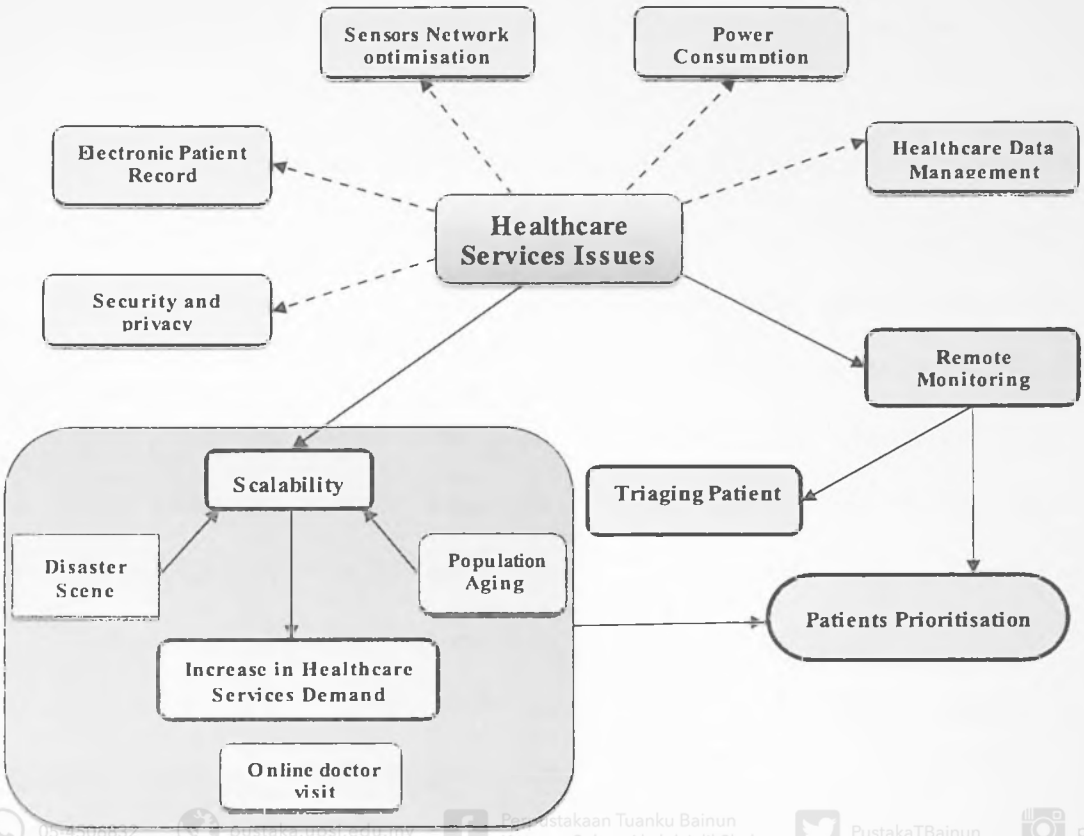


Figure 2.5. Taxonomy of Healthcare Service Challenges and Scalability Problem Module

Telemonitoring systems face many serious issues; one of them is patient prioritisation in healthcare service scalability (O. H. Salman et al., 2014). The increasing demand for healthcare service has resulted in the essential need for potential and scalable healthcare services (Sangjin Jeong et al., 2012; Van Dyk, 2014). Thus, the description of patient prioritisation in healthcare services scalability challenges, as shown in the subsection below.

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2.6.2.1 Patient Prioritisation in Healthcare Services Scalability Concerns

One of the main challenges in providing healthcare service is scalability, particularly in the processes of patient prioritisation (O. H. Salman et al., 2014). With the growing demand for healthcare service, medical services that are highly effective and scalable are seriously needed (Sangjin Jeong et al., 2012; Van Dyk, 2014). Many research have been conducted to enhance the prioritisation of patients in telemedicine context, as well as resolve the scalability issues (O. H. Salman et al., 2014). The dilemma of the growing number of elderly people who need timely and effective telemedicine services has been discussed in literature. The increase in the number of patients is estimated to happen in various cases, such as disasters and aging population, as illustrated in Figure 2.6 and presented in subsections below.

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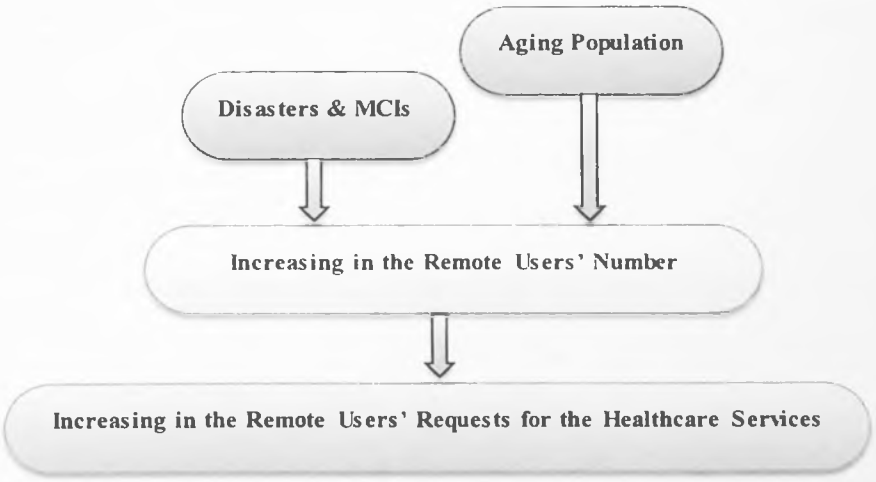


Figure 2.6. Problems that Cause the Increase in Users' Request in RHMSs

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2.6.2.1.1 Aging Population

Healthcare services suffer from massive challenges due to the increase in the number of patients (Mazomenos et al., 2013; Seising & Tabacchi, 2013; X. Wang, Gui, Liu, Jin, & Chen, 2014). The healthcare professionals have to use any advanced system effectively to meet the increasing system demand (Barbera, Joseph A. & Macintyre, 2004). The key reasons of the continuous growth of older generation sets were current demographic changes (Klimova, 2016) that cause persistent and earnest problems, such as incidence of aging diseases and social and economic burdens (Chung & Liu, 2013; Klimova, 2016; Sun, Guo, Wang, & Zeng, 2016). A study found an increase in the number of people aging 45 years or more by 11% in the last contract (Spending, 2009); the percentage of visits by physicians in this age range for the same duration also increased by 26%.

As the number of patients in healthcare increases, the expenditure of patients for healthcare services also increases (Spending, 2009). Therefore, the increase in the number of elderly patients is a challenge in telemedicine systems (O. H. Salman et al., 2014). Globally, the society and the healthcare system are loaded with burdens derived from the ongoing aging population problems (Chung & Liu, 2013; Klimova, 2016; Sun et al., 2016). By 2030, 13% of the world total population is expected to be assigned to around one billion people aging 65 years or older (Parekh et al., 2011).

Numerous problems in chronic diseases are related to age emerging from the momentary rise of aging population, and they have a direct influence in identifying

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the medical healthcare expenses (Palozzi et al., 2017; Sparks, Celler, Okugami, Jayasena, & Varnfield, 2016; Touati & Tabish, 2013). The increase of chronic disease cases along with the increase of aging population (e.g. heart failure, hypertension and diabetes) makes the healthcare management a serious issue for health systems worldwide (Palozzi et al., 2017). Based on Medicare and Medicaid Services Centre (Spending, 2009), healthcare expenditure in the USA in 1970 was around $75 billion, and it increased more than $4.3 trillion in 2018, as shown in Figure 2.7.

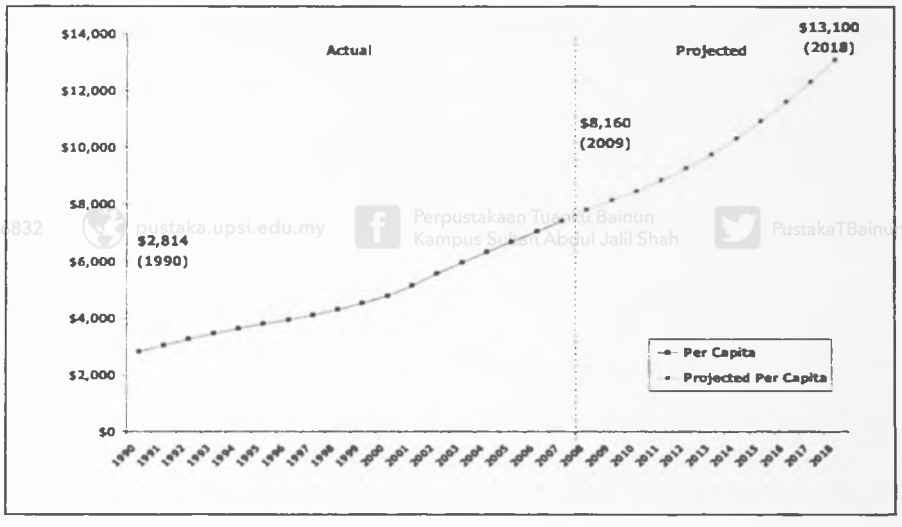


Figure 2.7. National Healthcare Expenditure Per Capita in the USA

An aging population suffering from long-term adverse situations is a serious Challenge to global healthcare systems in terms of care delivery quality (Spending, 2009; Touati & Tabish, 2013). Growing in the senior citizens number leads to growing in the elderly patients' number in other side (O. H. Salman et al., 2014). Therefore, researchers have begun to examine how to improve healthcare-service

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provision systems in response to the aging-population problems. They have been investigating and discussing how to enhance the systems of healthcare-service provision responding to the aging-population issue. A system that could precisely identify heartbeat for elderly patient monitoring was proposed by (Shih, Chiang, Lin, & Lin, 2010).

2.6.2.1.2 Disasters and MCIs

Disasters cause injuries to considerably numerous people yearly. However, the provision of medical services for injured persons remains a concern (Sakanushi et al., 2013). In the study of (Shnayder, Chen, Lorincz, Fulford-Jones, & Welsh, 2005) a system that could be applied to monitor the pulse rate and SpO2 of casualties was proposed. Furthermore, another research by (Ahn, Heo, Lim, Seo, & Kim, 2008) proposed the use of a monitoring system for pulse rate and ECG of casualties. These systems could then be used to transfer data to the server side. In such systems, the rescue commanders could monitor the casualties in real time. However, the casualties are not prioritised accordingly. The authors in (MartiN-Campillo, Crowcroft, Yoneki, & Martí, 2013) demonstrated how various characteristics for an emergency scenario influence the protocol behaviour; they compared and contrasted the efficiency of common opportunistic routing protocols by simulations in scenarios of realistic disaster. The study of (Xiang & Zhuang, 2014) proposed the network for queuing for the health condition of victims in the disaster aftermath. An electronic triage system was also proposed by (Shnayder et al., 2005). This system is composed of two types,

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namely, the electronic triage (E-Triage) tags and E-Triage server. The attached E-Triage tags, which support the monitoring of vital signs for casualties, enables offices to identify a casualty whose physiological condition is drastically changing requiring for a rapid response. However, a detailed triage mode is insufficient in mass casualties or in cases in which a triage officer is late. Therefore, identifying new risk evaluation and classification systems would better enhance the interventions and assist patients, caregivers and their providers in disaster preparation (Wyte-Lake, Claver, & Dobalian, 2016). In MCI, patients under remote monitoring might face disruption with the support services required (Zane & Biddinger, 2011). In healthcare systems, no enough capacity is available to immediately provide elective healthcare services for the causalities; one way to solve such problem is to prioritise the patients remotely to deal with the crowding in case of scalability concerns (Hansen, Hendry, Naden, Ombler, & Stewart, 2012; O. H. Salman et al., 2014).

2.6.3 Critical Review and Analysis

This section shows a critical review and deep analysis of the telemedicine application review. Physicians/nurses have no time search for all huge records and vital signs of all the patients, particularly for large-scale patients with emergency conditions; therefore, a support is needed to focus their attention and their efforts to provide the best care and discern on which patients need immediate care and which patients can wait. To handle these issues, a prioritisation process is utilised in telemedicine environment to rank the patients and arrange them according to their severity and to

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facilitate the process of distinguishing the patients with the most emergency condition.

Based on the systematic literature review, the studies by (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018; O. H. Salman et al., 2014) are considered the most relevant in this area. Such studies addressed patient prioritisation in a remote-monitoring environment and identified those who had CHD. However, such prioritisation solution can only address prioritisation on patients with single chronic disease. Moreover, in the study of (O. H. Salman et al., 2014), the patients were prioritised using a PC with a range of 0–100. However, only patients with this range can be prioritised, whereas those with the same PC value were sorted in a descending order by using the FCFS approach. Moreover, FCFS cannot be used in reality, considering that some patients may have more urgent cases than the others who arrived earlier (D Claudio & Okudan, 2010; Tan et al., 2013).

Meanwhile, the study of (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018) presented a new approach to prioritise large-scale data of patients with CHDs by using body sensors during disasters and peak seasons. The patients in this study were scored according to the MCDM techniques, namely, integrated analytic hierarchy process (AHP) and TOPSIS. However, one major problem in this study is that the proposed approach can only prioritise those patients with single chronic disease; therefore, this approach cannot determine the emergency degree of each chronic disease individually to accurately prioritise patients with MCDs.

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This research has not come across any other research that has exclusively presented a solution for remote prioritisation in a large scale of patients with MCDs, especially in the server side of telemedicine applications (Tier 3). Such issue, if handled and addressed, can save lives, among other advantages.

Furthermore, (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018) recommended to adopt a decision-making platform for different chronic diseases (myocardial infarction, diabetes and high or low BP). This platform can be used for patient prioritisation, considering the different diseases and emergency levels of each patient. As mentioned, the present study aims to introduce improvements in the prioritisation process for patients with MCDs in the server (Tier 3) through designing and refinement to accommodate patient's requests and strictly prioritise and rank patients with emergency conditions. Finally, in line with the relevant study in the remote monitoring environment, the MCDs have been set as a case study for this research as a proof of concept. Further investigation on RHM over telemedicine and the case study is demonstrated in the following section.

2.7 MCDs in RHM

Patients may experience various chronic diseases, including diabetes, chronic BP disease, CHD and fall detection. Chronic diseases have become a growing serious concern in E-Systems of healthcare worldwide. For instance, clinical expenses of the chronic diseases in the USA are projected to reach 80% of the total medical costs, and

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more than 150 million people may have chronic diseases by 2020 (Nguyen, Khosravi, Creighton, & Nahavandi, 2015). Moreover, health systems and individuals bear huge burdens by chronic diseases due to the frequent visits of patients, who have chronic disease, to the ED that are frequently unscheduled, as well as lengthy admissions in hospital (Mciver et al., 2012; Van Dyk, 2014).

Healthcare researchers and practitioners have been working on health monitoring applications out-of-hospital, particularly in the home environment, for a long time. Telemedicine requires continuous monitoring of the data relevant to physiological conditions; these data could be used to manage chronic diseases (Patel, Park, Bonato, Chan, & Rodgers, 2012). Patients whom their homes are situated far from hospitals and who utilise telemedicine may have various chronic cases, such as chronic BP, CHD and diabetes (Baig & Gholamhosseini, 2013; Okura et al., 2016). Thus, we present a scope for two popular chronic diseases from two perspectives, namely, medical and chronic diseases, as presented in the next subsections.

2.7.1 CHD

Around 12 million people die around the world annually due to CHDs (Nguyen et al., 2015). CHD consists of several kinds, and disease symptoms can appear in patients. For instance, 'cardiac arrhythmia' is an emergency case that can be life threatening, possibly leading to sudden death and cardiac arrest. According to the American Heart Association (2010), arrhythmia caused the death of around 55% of patients who had

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heart disease (Baig & Gholamhosseini, 2013). Serious cases of arrhythmia such as fibrillation or ventricular tachycardia are common results of vortex-like re-entrant electric waves in the cardiac tissue. Rapid diagnosis of CHDs is crucially needed in the actual medical field due to the impact of heart disease to the health and working performance of patients, particularly the elderly patients (Nguyen et al., 2015). Telemedicine plays a pivotal role in the delivery of efficient healthcare in patients with many branches of cardiologic disease (Natale Daniele Brunetti et al., 2015). Numerous research discuss the involvement of remote monitoring in the management of cardiac diseases and cardiac home cures, demonstrating that remote monitoring is suitable in terms of cost effectiveness for the same health outcome. Moreover, telemedicine methods yielded worthy effects in chronic heart failure care (Winkler et al., 2011). In-home telemonitoring also reduces both mortality and hospitalisation (Winkler et al., 2011).

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2.7.2 Chronic BP Disease

Around 40% of people worldwide, aged over 25 years, have hypertension (Alwan & Others, 2011). In general, low-income countries have weak dominance of hypertension (35%) than other countries at 40% (Alwan & Others, 2011; Organization & Others, 2008). Moreover, the largest percentage of people with hypertension who are uncontrolled, untreated and undiagnosed is higher in low-income countries due to poor health applications and systems compared with those in high-income countries. This rise in the distribution of hypertension is due to population growth, ageing and

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behavioural risk factors (World Health Organization, 1953). In summary, deaths caused by hypertension will increase if no appropriate action is taken. Rapid detection, suitable treatment and superior hypertension management can lead to important health and economic advantages. In previous studies, such as in the study by (Malhotra, Chan, Malhotra, & Østbye, 2010), hypertension correlated to 4494 elderly people who lived in Singapore. In their research, the group of persons who lived alone had a higher rate of untreated hypertension (37.3%) than those who did not live alone. A research by (Áurea, Pilar, José, & Fernando, 2005) discovered that the hypertension risk for elderly people who lived alone was greater than that for elderly people who got married or lived with others.

One common gradual path in managing hypertension is for patients living at home to measure their own BP and send the measurement results in real time to their caregivers. Research have clarified that monitoring of BP at home is as dependable and authoritative as ambulatory BP tracking (Czaja, Lee, Arana, Nair, & Sharit, 2014). This research suggests a telehealth system that transmits BP data to a server and provides a messaging function, which sends a daily reminder to patients. Moreover, in this research, users had a positive perception of the telehealth system usefulness and usability. Algorithms for health monitoring with the use of a BP sensor have been proposed in many research (Agrawal, 2013; Chan, Estève, Fourniols, Escriba, & Campo, 2012; Gao et al., 2007; O. H. Salman et al., 2014). Finally, clinical guidelines, as well as programs of disease management, cover only single diseases, and clinical studies often excludes people with MCDs (Vogeli et al., 2007). However, MCDs (e.g. CHD, high BP and low BP) have been set as a case study in this research,

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considering that it is the leading cause of death worldwide. The sources used to measure vital signs and provided to patients with MCDs are further described and summarised in the next section.

2.8 Sources Used to Measure Patients' Medical Vital Signs

Continuous monitoring of health in WBAN needs the sensors of the system to work at all times (Rocha et al., 2011). To measure the vital signs of patients, healthcare professionals used many medical devices. In telemedicine applications, sensors play an important role, and patients may need to use various kinds of sensors (Rekha, Mathambigai, & Vidhyapriya, 2012; Touati & Tabish, 2013); The kind and number of sensors that are required for patient monitoring differ from one disease to another. According to (O. H. Salman et al., 2014) stated that four medical sources related to CHD need to be identified and validated; three sensors were utilised as signal sources, and one as a text source. A set of heterogeneous sources relevant to CHD can be applied in one healthcare platform, which is significant in healthcare monitoring (Azeez, Ali, Gan, & Saiboon, 2013; O. H. Salman et al., 2014). Table 2.1 illustrates the brief description of four related medical sources that can be used to triage patients with various chronic diseases.

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Table 2.1

Description of Relevant Medical Sources Used in Monitoring Patients

Source	Description	References
ECG Sensor	Measure the electrical representation of the contractile activity of the heart over time. An electrical representation of contractile activity is used for the short-term assessment of cardiovascular diseases, especially for people with chronic heart problems.	(N D Brunetti, Dellegrottaglie, Di Giuseppe, Antonelli, & Di Biase, 2014; Merzougui, 2015; O. H. Salman et al., 2014; Winkler et al., 2011).
SpO2 Sensor	The pulse oximeter is used to measure the blood oxygen saturation level of the patient.	(Merzougui, 2015; O. H. Salman et al., 2014; Winkler et al., 2011).
Blood Pressure Sensor	Measure the physiological data of the systolic and diastolic blood pressure of the patient.	(Merzougui, 2015; O. H. Salman et al., 2014; Winkler et al., 2011).
Text	Non-sensory measurements are used by triage nurses in the hospital (ED) to prioritize the patients according to several categories, such as chest pain.	(N D Brunetti et al., 2014; Godfrey, B., 2000; O. H. Salman et al., 2014).

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As shown in Table 2.1, several sensors, sources and text (heterogeneous sources) are needed in this study. These sources present the diagnosis and reflect the medical signs and symptoms of patients with MCDs. However, chronic BP values are important for RHM (Sani et al., 2014). Several studies presented algorithms for healthcare monitoring with the use of a BP sensor (Agrawal, 2013; Chan et al., 2012; Gao et al., 2007; O. H. Salman et al., 2014). The classification of the emergency levels of BP according to the American Heart Association (American Heart Association, 2014) is illustrated in Table 2.2.

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Table 2.2

Classification of Emergency BP levels

Blood Pressure Category	Systolic (mmHg)		Diastolic (mmHg)
Emergency care needed	>180	or	>110
Hypertension Stage 2	160-180	or	100-110
Hypertension Stage 1	140-159	or	91-99
Prehypotension	131-139	or	86-90
Normal	110-130	and	75-85
Prehypertension	109-90	or	76-60
Hypotension Stage 1	89-60	or	59-40
Hypotension Stage 2	59-50	or	39-33
Emergency care needed	<50	or	<33

Table 2.2 shows the ranges of emergency BP levels representing the systolic and diastolic levels with the related BP categories.

In conclusion, ECG, SPO2 and BP sensors are important, and they need to be employed in this research for CHD. Furthermore, in remote healthcare monitoring, nonsensory data are necessary (O. H. Salman et al., 2014), so that text data can be used as another medical source for the same disease, that is, CHD. Meanwhile, in chronic BP disease, sensors for systolic and diastolic BP can be used in this research to measure the emergency level of patients to enhance the accuracy of triage and healthcare services for patients who have MCDs. Moreover, connections between the complaints and the vital signs are operationalized as the changing relative significance of vital signs (Ashour & Okudan, 2010). Hence, each chronic disease (heterogeneous data) has different sources; sensors for MCDs and text should be engaged in this

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research. In addition, vital signs, such as SpO2 and ECG, have proven to be extremely important in the triage process because they provide an objective complement to the triage decision and optimise inter-rater consistency (Westergren, Ferm, & Häggström, 2014). For each source of these diseases, classifying the patients and their diagnostic information by using the triage process is needed. Triage protocols are used in determining the treatment priority of patients depending on the severity of their situations (Niswar et al., 2013). The triage system standards and guidelines provided to the patient with the MCDs are further described and summarised in the next section.

2.9 Triage System Standards and Guideline

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Various triage standards are presented and explored in Table 2.3. Their categories, domains and types are varied with respect to cases and diseases of patients worldwide.

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Table 2.3

State-of-the-Art Triage Systems

Triage System	Description	Triage performer	Domain	Type	Number of categories and their names
Early Warning Scorecard (EWS) (Christensen et al., 2011b)	EWS is a simple scoring system for bedside monitoring to serve as a clinical add-on using routinely collected vital sign data.	No specifications	Traditional	Paper based	1. Yellow 2. Orange 3. Red 4. Blue
Australian triage scales (ATS) (Hung, Chang, & Huang, 2006)	ATS is designed for hospital-based emergency services in Australia and New Zealand.	Triage nurse	Traditional	Paper based	1. Immediate 2. Very urgent 3. Urgent 4. Less urgent 5. Nonurgent
Canadian Triage and Acuity Scale (CTAS) (Beveridge et al., 1998)	CTAS is used by all Canadian EDs. The system mandates that every patient presented for care must be at least visually assessed within 10 min of presentation. Acuity assignment is based on the chief complaint and a focused subjective and objective assessment.	Physician/Nurse	Traditional	Paper based	1. Immediate 2. Very urgent 3. Urgent 4. Standard 5. Nonurgent

(Continue)

Table 2.3 *(Continue)*

Triage System	Description	Triage performer	Domain	Type	Number of categories and their names
Modified Early Warning Scorecard (MEWS) (Zarabzadeh et al., 2013)	MEWS is a modified version of EWS. Vital sign data are manually sampled and recorded	Medical staff	Traditional	Paper based	1. Low 2. Medium 3. High
Electronic Modified Early Warning Scorecard (eMEWS) (Zarabzadeh et al., 2013)	eMEWS represents the shift from paper-based warning scorecard systems to electronic systems. eMEWS is often designed and developed around the paper-based MEWS guidelines and associated protocols.	Medical staff	Traditional	Digital	Not specified
Medical Emergency Triage and Treatment System (METTS) (Widgren & Jourak, 2011)	METTS is developed at Sahlgrenska University Hospital and used in the ED since January 2005.	Physician/Nurse	Traditional	Paper based	1. Red 2. Orange 3. Yellow 4. Green 5. Blue
Emergency Severity Index (ESI) (R Seising & Tabacchi, 2013)	ESI is designed for use in ED triage by the US Department of Health and Human Services.	Triage nurse	Traditional	Paper based	1. Immediate 2. Emergent 3. Urgent 4. Semi urgent 5. Non urgent

(Continue)

Table 2.3 *(Continue)*

Triage System	Description	Triage performer	Domain	Type	Number of categories and their names
MSHA algorithm (Omar H Salman et al., 2014)	MHSA algorithm-based triage generates priority codes (PCs) that classify users according to the severity of their emergency cases.	Algorithm based guideline to generate PC	Remote	Digital	1. Red 2. Orange 3. Yellow 4. Blue 5. Green
Manchester triage system (MTS) (Zachariasse et al., 2017)	MTS is developed in 1994 by a group of professionals specialising in triage. It classifies risks into five categories.	Physician/Nurse	Traditional	Paper based	1. Immediate 2. Very urgent 3. Urgent 4. Standard 5. Non urgent
Bispebjerg Early Warning Score (BEWS) (Christensen et al., 2011a)	BEWS is used by the triage nurses in EDs to identify the severely injured and/or critically ill patients who must receive emergency or trauma care	Medical staff	Traditional	Paper based	Not specified
Simple triage and rapid treatment (START) (Benson, Koenig, & Schultz, 1996; Lerner et al., 2011; Sakanushi et al., 2013)	START is widely used, particularly during disasters, because it sorts the casualties into four categories without medical equipment.	Triage officers	MCI	Paper based	1. Immediate 2. Delayed 3. Minor 4. Deceased

(Continue)

Table 2.3 *(Continue)*

Triage System	Description	Triage performer	Domain	Type	Number of categories and their names
Sacco Triage Method (STM) (Lerner et al., 2011)	STM is an evidence-based outcome-driven triage and resource management system that maximises expected survivors in consideration of the timing, availability and capability of transport and treatment resources.	Medical staff	MCI	Paper based	Group 1: high rate of deterioration Group 2: moderate Group 2: slow
JumpSTART (Lerner et al., 2011)	Jump START is developed for paediatric patients 1–8 years old. Its structural design is parallel to that of START.	Triage officers	MCI	Paper based	1. Immediate: red 2. Delayed: yellow 3. Minor: green 4. Deceased: black
Paediatric Triage Tape (PTT) (Hodgetts, Hall, Maconochie, & Smart, 1998)	PTT relates the child's length to age-related changes in normal physiological values. The information is presented on a waterproof tape and can be used in conjunction with any existing triage label systems.	Medical staff	MCI	Paper based	Immediate: red Urgent: yellow Delayed: green Dead
Military Triage (Wiseman, Ellenbogen, & Shaffrey, 2002)	Classic military triage is based on a series of guidelines known as the conventional North American Treaty Organization triage classification.	Not specified	MCI	Paper based	Immediate Delayed Minor Expectant

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As shown in Table 3.3, only two triage systems are digital, whereas the remaining 13 utilised paper triages. Moreover, the majority of these systems have been used as a traditional triage inside the ED, whereas the standards PTT, STM, START, Military Triage and JumpSTART are conducted in case of disasters. Furthemore, six of these standards, namely, MSHA, CTAS, ATS, ESI, MTS and METTS, contain five categories; the three standards, namely, JumpSTART, START and EWS, contain four categories; and only MEWS contain three categories. The categories of other standards mentioned in the table above are not stated in the literature.

Even though paper triage tags are broadly conducted, they have several restrictions (Sakanushi, Hieda, & Shiraishi, 2012) and cannot be used in real-time monitoring in the telemedicine environment; only officers can use it, and gathering of vital signs is difficult. Consequently, digitalisation of the triage system, that is, eMEWS and MSHA, was generated (O. H. Salman et al., 2014).

Digitalisation of triage is essentially needed to deliver healthcare services based on their emergency and triage (O. H. Salman et al., 2014), particularly when it comprises several specifications as follows: (i) triaging of remote patients wherever they are; (ii) triaging patients by means of new features and symptoms; (iii) using sensory and nonsensory data to improve the guideline scores for chronic diseases; and (iv) improving the triage accuracy by using effectual mathematical theory and avoiding the use of human opinion. According to these specifications, MSHA

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algorithm has been proven a suitable standard for classifying and categorising patients.

According to the abovementioned specifications, MSHA algorithm will be adopted in this research, which will adopt five emergency levels, to obtain a triage level for patients with the CHDs. Meanwhile, medical guidelines will be adopted in this research to obtain a triage level for patients with chronic BP (systolic and diastolic BP).

2.10 Concern for Prioritisation Process

Recently, patient prioritisation in terms of MCDs has some shortcomings, considering that it still confronts problems and issues related to making multiple decisions. Patient prioritisation with MCDs cannot be solved in existing methods (method mentioned in Section 2.6.1.1) because of various diseases affecting each other. Prioritisation of MCDs in telemedicine applications is a difficult and challenging task because each patient has a multigroup triage of different diseases for evaluating their emergency status. This issue can be extended from a different side; decision makers (doctors) may give different weights for the mentioned diseases and multisource for each disease, thereby increasing the complexity of the task. Moreover, multigroup triage levels vary from one patient to another on the basis of the emergency status. For instance, data variation of multigroup triage for each patient occurs when patient A has a risk level for heart disease, urgent level for high BP and normal level for low

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BP, whereas patient B has an urgent level for heart disease, normal level for high BP and risk level for low BP. In this case, patient prioritisation is difficult due to having several levels in each patient. Patient A can be prioritised at the highest level on the basis of heart disease (first disease). In contrast, patient B can be prioritised at the highest level on the basis of low BP (third disease). In such case, a confusing question arises, that is, which patient will be prioritised first?

Finally, the proposed work aims to provide prioritisation for patients with MCDs patients, with simultaneous consideration of the triage levels from MCDs, thereby requiring multiple decision-making in identifying the emergency degree of each chronic disease for each patient. In such case, all patients have an available alternative for the decision-makers. Thus, prioritisation of patients with MCDs involves complex multiple-decision-making problems. Hence, multiple-criteria decision analysis is essentially needed to deal with this situation. Next section presents the suitability of the existing MCDM methods to solve the complexity of the prioritisation process for patients with MCDs.

2.11 MCDM: An Overview

In this section, the definition, advantages, challenges and techniques of MCDM are reviewed. The condition of the art of MCDM techniques in the healthcare application is also discussed.

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2.11.1 MCDM: Definition and Importance

The book by Keeney and Raiffa (Keeney & Raiffa, 1993) defines MCDM as 'an extension of decision technique that covers any decision with multiple objectives. A methodology for assessing alternatives on individual, often conflicting criteria, and combining them into one overall appraisal…' Another important definition was given by Stewart and Belton (Belton & Stewart, 2002), that is, 'an umbrella term to describe a collection of formal approaches that seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter.'

MCDM is considered one of the common techniques in decision-making, and it handles the problems depending to the available criteria (Malczewski, 1999; Petrovic-Lazarevic & Abraham, 2003). MCDM involves structuring, planning and solving decision problems by utilising numerous criteria (Malczewski, 1999). The purpose of MCDM is to support decision-makers to solve problems with numerous criteria and alternatives (Zionts, 1979). It uses a group of qualitative and quantitative methods to overcome the complex decision cases considering the multiple criteria, which might be conflicting (Baltussen & Niessen, 2006; Thokala et al., 2016). MCDM can enhance the quality of decisions; it provides the decision-makers to choose right decisions more effectively and rationally than the traditional processes (Oliveira, Fontes, & Pereira, 2014). MCDM includes (A) ranking the available alternatives and (B) determining the best alternative from available set of alternatives (Jadhav & Sonar, 2009; A. A. Zaidan, Karim, Ahmad, Zaidan, & Kiah, 2015). Accordingly, the suitable alternative(s) will be scored.

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MCDM, which was based on 'Health Science Policy Council' recommendation, was first used in healthcare in May 2014. MCDM involves many methods. Currently, it is increasingly used in the healthcare field. The task force aim was to present a foundational report on a topic, that is, an MCDM primer, and then focus on initial recommendations on how to best use the MCDM methods to support decision-making in healthcare.

Thus, the use of MCDM in healthcare has become familiar (Adunlin, Diaby, & Xiao, 2015; Diaby, Campbell, & Goeree, 2013). With the different available methods of MCDM, making healthcare decisions is more accurate; in addition, the ability of decision-makers has improved to obtain the best solution (Mühlbacher & Kaczynski, 2016).

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2.11.2 MCDM Techniques and Methods

Several MCDM techniques have been explored based on two directions, namely, ranking and weighting approaches.

- Ranking approaches are used to recognise the most suitable alternative or to rank the alternatives (Abdullateef, Elias, Mohamed, Zaidan, & Zaidan, 2016; Almahdi et al., 2019b; B. B. Zaidan, Zaidan, Abdul Karim, & Ahmad, 2017). In this approach, hierarchical adaptive weighting and simple additive weighting are used sequentially (Nedher, Hassan, & Katuk, 2014) to rank and select security controls where the organisation aims to address them suitably, whilst weighting of

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evaluation criteria is obtained directly from experts who provide opinion. Ref. (A. A. Zaidan, Zaidan, et al., 2015) presented a comparative study based on different MCDM techniques, such as weighted sum model, multiplicative exponential weighting and weighted product method to evaluate and select open-source electronic medical record (EMR) systems. In such comparative study, the mentioned MCDM techniques are used for ranking, whilst weighting for evaluation criteria are obtained based on AHP technique, which is used to extract weights from different experts. Ref. (D. S. Pamučar, Božanić, & Kurtov, 2016) presented a selection application based on TOPSIS to select the firing positions of an artillery brigade group in a defensive operation. In such application, an effective technique (a new extension of a Fuzzy-AHP) is required to acquire the relative importance of various criteria subjectively based on experts' opinion. This paper aims to assist the administration departments of medical organisations in making the right decision on selecting a suitable multiclass classification model for acute leukaemia. Ref. (Alsalem et al., 2019) proposed a new evaluation and benchmarking framework for multiclass classification models for acute leukaemia. In the proposed framework, vlsekriterijumska optimizacija i kompromisno resenje (VIKOR) is used to rank classification models, whilst best-worst method (BWM) is applied to solve the problem of VIKOR by subjectively providing weights for the evaluation criteria based on experts' preferences. Ref. (O. S. Albahri, Albahri, et al., 2019) produced a fault-tolerant framework on mHealth in the IoT environment to provide healthcare services from a suitable healthcare provider. The selection of a healthcare provider within mHealth is presented using AHP based on two stages. In the first stage, healthcare service criteria used in the

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selection process are weighted subjectively based on different experts. In the second stage, the available healthcare providers are ranked based on the weighted criteria. Ref. (Roy, Adhikary, Kar, & Pamucar, 2018) developed a rough strength relational DM and trial evaluation laboratory (RSR-DEMATEL) model to analyse the individual priorities of key success factors (KSFs) of hospital's performance measures. The modified DEMATEL method is beneficial to illuminate the relations amongst KSFs and ordering them depending on the cause/effect relations and prominence of their influence on other factors. DEMATEL method prioritises KSFs based on the type of relationships and the severity of influencing factors. An RSR is used to avoid the mentioned issue because of its uncertainty in the analysis of KSFs of hospital's performance measures. Ref. (Badi & Ballem, 2018) selected the best medical supplier among three other suppliers in Libya based on Multi-Attribute Ideal-Real Comparative Analysis (MAIRCA). In such selection, five criteria (cost, quality, supplier profile, delivery and flexibility) must be weighted to make an accurate selection. MAIRCA method lacks a weighting purpose; thus, modified rough BWM was utilised to extract weights from four experts subjectively. Ref. (Sremac, Stević, Pamučar, Arsić, & Matić, 2018) presented an evaluation and ranking of 10 logistics providers dealing with the transport of dangerous goods for chemical industry companies by using weighted aggregated sum product assessment (WASPAS) model based on a new rough Dombi Agregator. In such selection, the importance of eight attributes was determined by experts subjectively by a step-wise weight assessment ratio analysis (SWARA) method on the basis of the proposed rough Dombi Agregator. Ref. (D. Pamučar, Stević, & Zavadskas, 2018) presented a novel concept for evaluation and ranking

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of the 15 websites of faculties that form the University of East Sarajevo; this concept was named a hybrid Interval Rough Analytic Hierarchy Process – Multi-Attributive Border Approximation Area Comparison model. In this study, interval rough number is introduced to solve the uncertainty problem in DM. Moreover, IR-MABAC is applied to rank the web sites, whilst the adopted evaluation criteria are weighted based on IR-AHP to calculate weights from a group of experts. Ref. (Chatterjee, Pamucar, & Zavadskas, 2018) provided a rough number-based framework of DEMATEL-analysis network process (ANP) and MAIRCA approaches for evaluating the performance of suppliers for implementation of green supply chain in the electronics industry. A hybrid rough DEMATEL-ANP method is utilised for computing normalised evaluation criterion weights, and a rough MAIRCA method is utilised for ordering the available alternatives based on the weight values of the adopted criteria. Ref. (Stević, Pamučar, Subotić, Antuchevičiene, & Zavadskas, 2018) proposed a method for evaluation and selection of potential locations for roundabout construction using MCDM techniques. The authors in the mentioned study used Rough BWM method to determine the relative criterion weights subjectively based on seven experts and Rough WASPAS to rank the available locations. Moreover, a new Rough Hamy aggregator was developed to enable the most precise consensus for group DM. Ref. (D. Pamučar, Sremac, Stević, Ćirović, & Tomić, n.d.) presented a method for evaluation and selection of 21 safety advisors for the transport of hazardous materials in Serbia by using a new model that integrates Linguistic Neutrosophic Numbers and WASPAS method. WASPAS method was utilised for ranking the 21

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safety advisors, whilst the authors used LNN model to determine the weights of nine criteria from the opinion of seven experts.

In the weighting approaches, the weights of attributes represent the relative importance among them (Almahdi et al., 2019a; Alsalem et al., 2019). In evaluation and DM, these weights reflect the status and effect of each attribute on DM (Yas, Zaidan, Zaidan, Rahmatullah, & Abdul Karim, 2018; A. A. Zaidan et al., 2019). In general, two methods, namely, subjective and objective assessments, can be used to identify criteria weights. Subjective assessment provides weight to attributes according to the experience of decision-makers and subjective importance to each attribute. Subjective weights reflect accumulated experience of decision-makers and subjective judgment to present DM background. Ref. (Massawe, Kaaya, & Slater, 2019) used MCDM approach based on AHP to obtain scores of comparative importance of criteria for an appropriate land for rice production based on three expert groups, namely, extension staff, farmers and hybrid among them. ANP method was used by (Namin et al., 2019) to solve the problem of independency and dependency between factors of the SWOT model; such method assesses the possible dependencies among all available factors. Ref. (Zolfani & Saparauskas, 2013) developed a new framework for evaluating and prioritising sustainability assessment indicators of energy systems. In such framework, SWARA method is used to determine the importance of criteria and relative weights of each. SWARA's perspective is different from other similar methods like AHP and ANP; SWARA gives the chance for decision and policy makers to select their priority based on the current environment and economic situation. BWM is provided by (van de Kaa, Rezaei, Taebi, van de Poel, &

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Kizhakenath, 2019) as a suitable method for identifying the weights of different criteria (i.e. sociopolitical, market and household acceptance) of the case of smart meters based on expert opinion. Objective assessment method takes advantage of the information on each criterion to determine the weights of criteria. It does not depend on the subjective judgment of decision-makers in assigning the weights. The weights are directly assigned to attributes by a mathematical method. In such approach, integrated Criteria Importance Through Intercriteria Correlation-Entropy methods are employed by (Z. Lin et al., 2017) to determine the importance degrees of nodes in a power grid case study in order to reflect the differences and correlations among multiple indexes.

According to the explanation above, the benefit of ranking approaches is appropriate for situations with many alternatives and attributes (Jumaah et al., 2017; Rahmatullah et al., 2017; Zaidan et al., 2019). These methods have the capability to find the best alternative rapidly, and these techniques are considered the best among others. The mentioned methods are also specifically convenient to use when quantitative or objective data are given. These methods are functionally related to discrete-alternative problems. However, the major drawbacks of these ranking approaches include the lack of provision to weight elicitation and the consistency of judgments. In order to avoid this limitations, the literature review studies used external weighting techniques to improve the performance of the original ranking approaches through producing the importance of several criteria with respect to the objective; weighting approaches provide such a procedure (Alsalem et al., 2018; A. A. Zaidan et al., 2018). Furthermore, the benefit of other weighting techniques in both

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subjective and objective approaches can provide different weights for the adopted criteria to increase the performance of the DM process effectively. However, these techniques cannot be used to rank the available alternative individually. The explanation above applies to all MCDM techniques, except AHP. As shown in the literature, AHP technique was used for two directions, ranking and weighting purposes (O. S. Albahri, Albahri, et al., 2019). AHP was utilised to provide weights for criteria according to the preferences of experts and is remarkably restricted by the capacity of humans for processing information. However, AHP has an incredible drawback if used in the ranking purpose, which is inconvenient to use when dynamic data are provided in the DM process. This method is only used when static data are provided in the decision matrix. However, all existing ranking techniques, including AHP, cannot determine and break the decision into sub-decisions to guarantee the accuracy of the prioritisation process and determine the accurate emergency degree for patients with MCDs that represents multiple-DM problem (Mohammed et al., 2019), which is considered a technical gap. Although VIKOR technique produces balance between the overall utility and minimises the regret level (A. S. Albahri et al., 2018), assigning high priority for patient n more than patient m, in case of patient n is more risky when compared to patient m. Therefore, alternative solution is needed to prioritise the patients with MCDs. The proposed decision technique will be presented in details in the chapter three.

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2.12 Chapter Summary

To achieve the first objective of the research study, a literature review was presented. This review described the environment of the research study. In the first stage, based on the systematic review, there is no study presented solution for remote prioritization as the ability to rank a large scale of patients with MCDs, especially in the server side of telemedicine applications (Tier 3).

In the second stage, remote monitoring has been discussed and MCDs, namely, heart chronic disease, high BP and low BP have been identified as a case study.

In the third stage, this chapter also highlighted that the multiple decisions making problem is considers the open issue and challenge for patients' prioritization for telemedicine environment. As a result from this stage, there is a need to use a decision-making analysis as a solution that can solve the complex situation and deal with this issue.

The fourth stage discusses MCDM techniques. Here, the analysis after reviewing the MCDM techniques, the existing methods cannot use in the prioritization process of MCDs. Thus, the finding of this stage is there is an essential need to present a new decision technique to prioritize the patients with MCDs. The methodology for this research has been discussed in the next chapter.

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CHAPTER 3

RESEARCH METHODOLOGY

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3.1 Introduction

This chapter presents an overview and explanation of the proposed prioritisation of MCDs patients in telemedicine applications, which comprises four phases. The first phase (preliminary study) dealt with identifying and describing the research problem (Section 3.2). The second phase (Decision Technique) presents the proposed decision technique, namely, technique for reorganising opinion order to interval levels (TROOIL) to solve the multiple decision-making problems in Section 3.3. The third phase (Prioritisation of MCDs Patients) based on the proposed decision technique (TROOIL) are presented. This phase includes the targeted tier, patient dataset and converting actual data into triage patients with MCDs in (Section 3.4).

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Finally, the fourth phase (validation and evaluation) is set to validate and evaluate the performance of the proposed work, as presented in Section 3.5. A summary of this chapter is given in Section 3.6. The mentioned phases are summarised in Figure 3.1 and explained in the subsequent sections.

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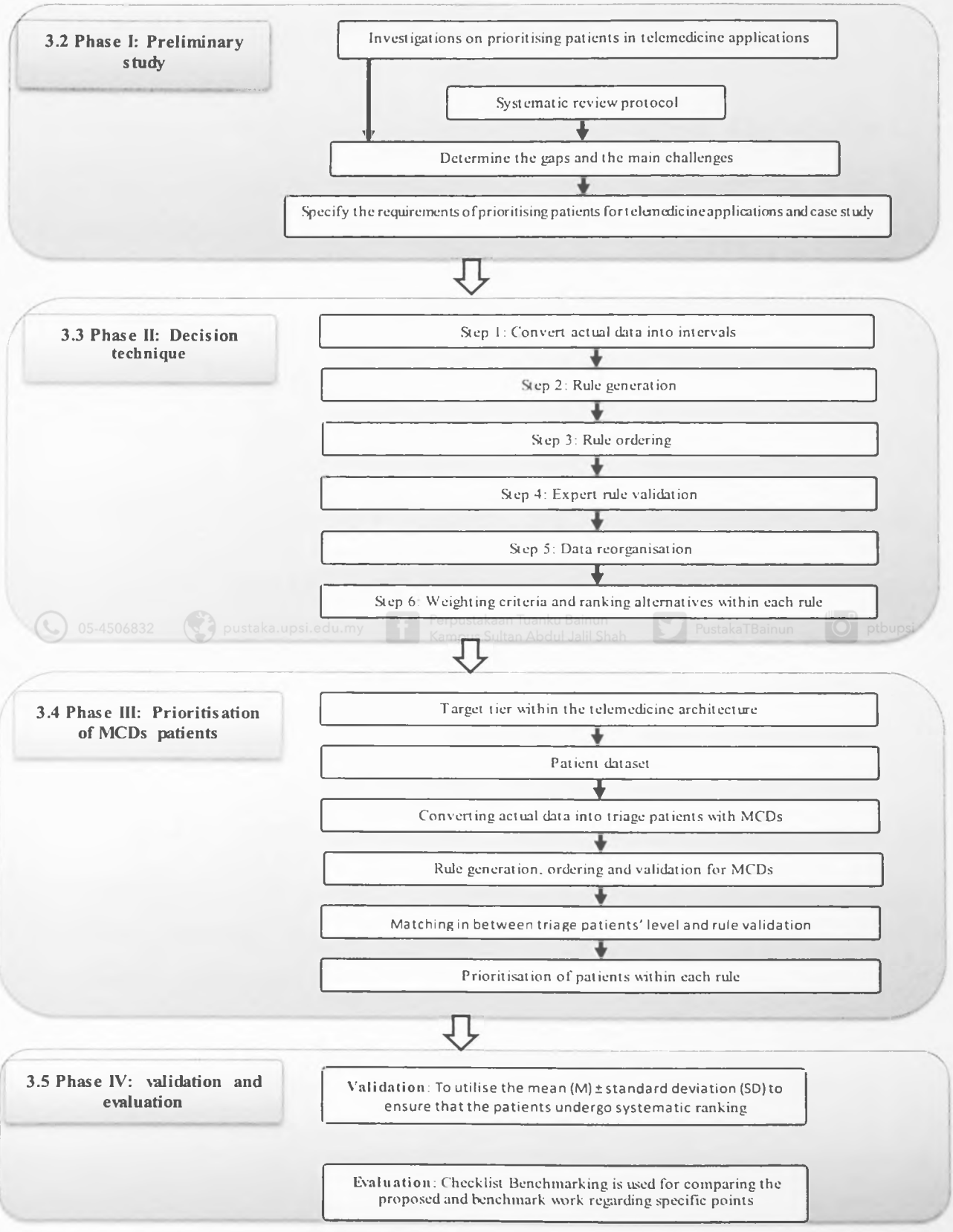


Figure 3.1. Research Methodology Phases

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3.2 Phase I: Preliminary Study

A preliminary study is required to investigate the previous methods developed for the existing technologies for prioritising patients in telemedicine applications to achieve the first objective. In this study, a systematic review protocol in telemedicine application is scrutinised. Then, a critical analysis has been conducted to determine the gaps and the main challenges in using remote prioritisation methods for MCDs. Besides, with a case study, the requirements for prioritising patients with MCDs for telemedicine were further explored. The content of the preliminary study phase is part of the literature review as detailed in Chapters 1 and 2.

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3.3 Phase II: Decision Technique

This section presents the proposed decision technique, TROOIL, to solve the multiple DM problems as mentioned in Section 2.10. The mathematical presentation for TROOIL is also presented in this section. The purpose of this phase is the model formulation process to assumptions, variables and parameters. The behaviour of precise mathematical presentation can be analysed using mathematical methods and computer simulations. In this section, fundamental terms should be defined, such as the decision matrix, alternatives and criteria. A decision matrix that consists of m alternatives and n criteria must be created. The intersection of each alternative and criteria is given as x_{ij}; therefore, the matrix is defined as $(x_{ij})_{m\times n}$.

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$$\mathrm{DM} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \end{array} \tag{3.1}$$

Where A_1, A_2, A_3,....A_m are the possible alternatives, $C_1, C_2, \dots, C_n$ are the criteria and x_{ij} is the rating of alternative A_i with respect to criterion C_j.

Assuming the set of alternatives A_i, i =*1, 2, 3....m*. A_n, A_k are two alternatives at different category levels, $n, k \in i$. S is a score function applied to A_i. The total score of $S(A_n) > S(A_k)$, and A_k is more risky than A_k. A_k dominates A_n, but the total score with actual values tells a different story. This case is possible only when the total achievement of A_i is high, but the importance of particular A_i is low; this problem is also known as 'distances relative importance problem'. Similar cases have been reported when using TOPSIS (Opricovic & Tzeng, 2004).

Although VIKOR technique produces balance between the total utility and minimises the regret level, it does not guarantee that $\forall_i, S(A_n) < S(A_k)$ when A_k is more risky than A_n. Therefore, a particular variable should break the matrix into submatrices to ensure that the highest achievement of A_k would not go higher than $A_n$despite the achievement of A_n. The steps involved in the decision technique phase are described in detail in the subsequent sections.

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Step 1: Converting Actual Data into Intervals

In this step, actual data acquired from the source are converted into intervals based on the level of achievement. This conversion might be done through expert, guidelines, medical trials and academic literature. This conversion generates semi order and probabilistic rules. These rules are then processed in the next steps, assuming that $z_n = [a_i, b_i] = \{x, n \in \mathbb{R}\ a_i \leq x_i \leq b_i\}$, *where n=number of cratieria.*

Step 2: Rule Generation

In this step, alternative (m) and criteria n will be identified. An item with (m) multiple alternatives has m choices each time. Choosing n of criteria that has m different alternatives has the following formula:

$$m \times m \times \ldots (n \text{ times}) = m^n \tag{3.2}$$

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The rule generation can be calculated using Equation (3.3) as follows:

$$R = m^n \tag{3.3}$$

Equation (3.3) is applied when each alternative is categorised according to similar number of options.

If the number of intervals per criterion is different, the number of rules is the product of multiplying the number of the interval in each criterion by the number of other criterion options. Therefore, the general number of rule generation can be calculated using Equation (3.4) as follows:

$$R = \prod_{p=1}^{n} C_p \tag{3.4}$$

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The following Vector (R) is obtained:

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ \vdots \\ \vdots \\ R_p \end{bmatrix} \tag{3.5}$$

In this case, if we assume p_i is a patient in a higher rule order compared with patient p_j, the final score of p_j at any mean would not achieve a better score than p_i.

Step 3: Rule Ordering

In this stage, rule ordering will be established. Rule ordering has two scenarios that heavily depend on the type of data (i.e. static data and dynamic data). In the first scenario (i.e. static data), the data are distributed based on the rules before they are sent to the expert. Only rules that have one alternative or more are selected, but rules with no data are neglected. Moreover, in case static data scenario is used, data reorganization step must adopt firstly followed by the expert rule validation step. This scenario can be used to reduce the number of rules before expert ranking to decrease the subjectivity, inconsistency and uncertainty problems associated with human perspectives in MCDM technique. Unlike the first scenario, rules in the second scenario are sent directly to the expert. Upon the completion of rule ranking, the original data are then distributed on the ordered rules. In case of data are dynamic, then an alternative might appear at any rule; in this case, ranking all rules is a must. Moreover, in case dynamic data scenario is used, expert rule validation step must adopt firstly followed by the data reorganization step.

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Step 4: Expert Rule Validation

In this step, the rules are prioritised from the highest to the lowest according to expert opinion to ensure that the ranked rules are accurate. The experts rely on their experience and knowledge to confirm the order of the rules and ensure that the higher order rules the higher priority level.

Step 5: Data Reorganisation

Alternatives will be organised based on the rule order; each alternative will be matched with the corresponding rule.

Step 6: Weighting Criteria and Ranking Alternative within Each Rule

Each case study has several alternatives that must be prioritised. In case of different alternatives within the same rule, a method must calculate criteria weights with respect to the goal in order to determine how each of them contributes to this particular decision. In this stage, several points are involved to assign proper weights objectively to the multisource criteria and then to rank the alternatives in a suitable way.

- Standardisation of data

Firstly, standardisation of the patient data is necessary now that the data of the patient criteria are not uniform and cannot be processed. In case of the benefit criteria, the data will be standardised according to the following method:

$$r_{ij} = \frac{x_{ij}}{max_j \; x_{ij}} \, , (i = 1, \dots, m; j = 1, \dots, n) \tag{3.6}$$

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In the case of the cost criteria, the data will be standardised according to the following method:

$$r_{ij} = \frac{min_j \; x_{ij}}{x_{ij}} \;, min_j \; x_{ij} \; \neq 0 \;, (i = 1, \dots, m; j = 1, \dots, n) \tag{3.7}$$

Through this operation, all of the data are in the [0, 1] range, which resulted in the standardised matrix $\dot{R} = [r_{ij}]_{m \times n}$.

- Calculate entropy of information

Entropy of information is an important factor for measuring the weight of criteria. High entropy of information indicates that the information provided by the criteria in the comprehensive score is large and the weight is higher. The equation below indicates how to calculate entropy of information (e_j).

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$$e_j = -\frac{\sum_{i=1}^{m} f_{ij} \ln f_{ij}}{\ln m} \; i = 1,2, \dots, m \; and \; j = 1,2, \dots, n \tag{3.8}$$

$$where:$$

$$f_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \quad and \; 0 < e_j < 1$$

If f_{ij} values are equal, then the entropy values of each criterion is maximum ($e_j = 1$). If f_{ij} is 0, then f_{ij} ln f_{ij} is 0 (Wu, Sun, Liang, & Zha, 2011).

- Calculation of weight

After calculation of the information entropy, the weight of each criterion (w_j) is determined via the entropy approach, which reflects the importance of the attributes in the proposed technique.

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$$w_j = \frac{1 - e_j}{n - \sum_{i=1}^{m} e_j} \quad where \sum_{j=1}^{n} w_j = 1 \tag{3.9}$$

where n is the number of criteria.

- Comprehensive score

The comprehensive score can be obtained based on weight. Equation (3.10) will be used to determine the weighted matrix: $WM = [wm_{ij}]_{m \times n}$.

$$WM = \sum_{j=1}^{n} r_{ij} w_j \tag{3.10}$$

Obtaining a comprehensive score of each alternative within each rule based on the calculated weights is reasonable. In such case, a decision matrix will be constructed based on a crossover of multiple criteria and alternatives.

The alternatives will be ranked on the basis of direct aggregation technique (i.e. arithmetic mean), as shown in Equation (3.11).

$$A_{m(x)} = \frac{\sum_{i=1}^{n} wm_i}{n} \tag{3.11}$$

Finally, the set of alternatives $A_{m(x)}$ can now be ranked according to their score in descending order; the highest value indicates optimal performance.

3.4 Phase III: Prioritisation of Patients with MCDs

This phase presents the prioritisation of patients with MCDs based on TROOIL. This phase presents the targeted tier, patient dataset, actual data conversion into triage patients with MCDs, rule generation, ordering and validation for MCDs, identification

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of patient triage with a corresponding rule and prioritisations of patients over rules. The steps involved in this phase are described in detail in the subsequent sections.

3.4.1 Targeted Tier within the Telemedicine Architecture

The telemedicine architectures used in this research consist of three tiers as follows: sensor based (Tier 1); gateway based (Tier 2), which represent the client side and server-based (Tier 3), which represents remote server. Data from the medical sensors and manual inputs (text) are collected from the patient on the client side (Tier 1 and Tier 2). All data are then sent to the server for processing. In the server (Tier 3), data from sensors are analysed. Tier 3 involves a remote computer for real-time monitoring. Remote monitoring enables medical professionals to analyse data in real time and provides patients with MCDs with compatible services. The server commonly includes the user medical records, user history reports and the database (Touati & Tabish, 2013). Tier 3 is the targeted tier in this research. The process in the server is an estimation of the medical situation of the patients with MCDs, resulting in prioritising the patients according to their urgent cases. The high-level abstract of the telemedicine architecture is presented in Figure 3.2.

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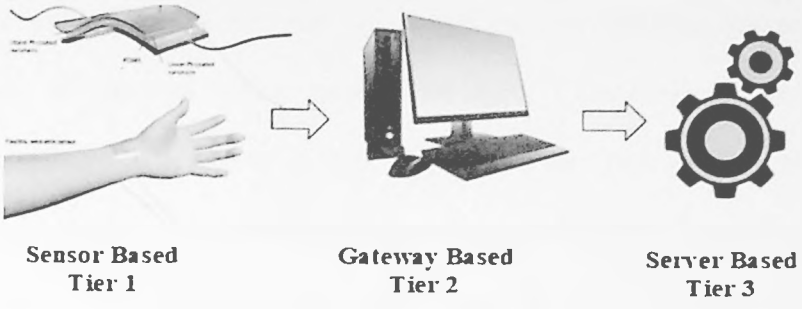


Figure 3.2. High-Level Abstract of the Telemedicine Architecture

3.4.2 Patients Dataset

In this section, the type and number of patients have been specified. The dataset of 500 patients is adopted from the most relevant study in the remote prioritisation area (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018). This dataset varied in several aspects, such as gender, age, patient location and available medical history in the hospital server. For all datasets used, males constituted 60% of the dataset and females constituted the remaining 40%. A total of 50% of the patients were 40–65 years old, 40% of the patients were older than 65 years old and 10% of the patients were under 40 years old.

Patients identified by this research are remote patients with MCDs. The adapted dataset contains three diseases (i.e. CHD, high blood pressure and low blood pressure) presented in two parts. The first part is CHD. Sensors (ECG, SPO2 and BP) and texts are used to transfer patient vital signs and complaints to the healthcare providers to monitor and assess their situation.

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The second part is high and low blood pressure diseases. Sensors for systolic and diastolic are used to transfer patient vital signs to the healthcare providers at the same time with the first dataset (CHD). The dataset for high and low blood pressure diseases (i.e. systolic and diastolic) are derived from the heart disease dataset due to related blood pressure diseases that might cause the heart diseases (Lawes, Vander Hoorn, & Rodgers, 2008). The CHD in this research includes blood pressure measurements. In this thesis, high blood pressure and low blood pressure were considered as separate chronic diseases. The same number of patients (500) has been involved in this research for blood pressure disease.

3.4.3 Converting Actual Data into Triage Patients with MCDs

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In this section, actual data acquired from the source of MCDs are converted into triage patients' level with MCDs. The conversion process is based on two stages. In the first stage, MSHA algorithm mentioned in Section (2.9) is used to determine the triage level for CHD. In the second stage, medical guidelines will be utilised to determine the triage level for chronic blood pressure (i.e., systolic and diastolic), as mentioned in Section (2.8). The following subsections illustrate in details the conversion process for MCDs.

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3.4.3.1 Stage I: Triaging Patients with CHD Based on MSHA Algorithm

In this stage, MSHA algorithm will be adopted in Tier 3 to obtain the triage level for the CHD patients. MSHA is one of the most significant algorithms for categorising and triaging patients. This algorithm is implemented based on evidence theory. The output of MSHA algorithm is represented as priority code (PC) value. In this stage, the PC value for each patient is used to identify the final triage level for patients with CHDs, namely, risk, urgent, sick, cold state and normal, as shown in Table 3.1.

Table 3.1

Triage Levels for CHD-based MSHA

Triage level	Description
Level 1	IF PC value ≤ 2 THEN the triage level of patient is normal
Level 2	IF PC value ≥ 3 and PC value ≤ 25, THEN the triage level of patient is cold
Level 3	IF PC value ≥ 26 and PC value ≤ 50 THEN the triage level of patient is sick
Level 4	IF PC value ≥ 51 And pc value ≤ 65 THEN the triage level of patient is urgent
Level 5	IF PC value ≥ 66 and PC value ≤ 100 THEN the triage level of patient is risk

Table 3.1 shows the five levels of triage. For the first level (normal), the PC value is lower than or equal to two. For the second level (cold state), the PC value is highest than or equal to three and lower than or equal to 25. For the third level (sick), the PC value is higher than or equal to 26 and lower than or equal to 50. For the fourth level (urgent), the PC value is higher than or equal to 51 and lower than or equal to 65.

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For the fifth level (risk), the PC value is higher than or equal to 66 and lower than or equal to 100.

3.4.2 Stage II: Triaging Patient with High and Low Bp Diseases Based on Medical Guidelines

In this stage, medical guidelines are used to determine the triage level for patients with high and low blood pressure diseases. The medical guidelines listed by the American Heart Association can be used to classify the emergency level for blood pressure diseases as shown in Table 3.2

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Table 3.2

Triage Levels for High and Low BP-based Medical Guidelines

Triage level	High BP	Low BP
Level 1	IF High BP value 110–130	IF Low BP value 75–85
	THEN the triage level of patient is normal	THEN the triage level of patient is normal
Level 2	IF High BP value 131–139	IF Low BP value 86–90
	OR High BP value 109–90	OR Low BP value 76–60
	THEN the triage level of patient is cold	THEN the triage level of patient is cold
Level 3	IF High BP value 140–159	IF Low BP value 91–99
	OR High BP value 89–60	OR Low BP value 59–40
	THEN the triage level of patient is sick	THEN the triage level of patient is sick
Level 4	IF High BP value 160–180	IF Low BP value 100–110
	OR High BP value 59-50	OR Low BP value 39–33
	THEN the triage level of patient is urgent	THEN the triage level of patient is urgent
Level 5	IF High BP value >180	IF Low BP value >110
	OR High BP value <50	OR Low BP value <33
	THEN the triage level of patient is risk	THEN the triage level of patient is risk

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Table 3.2 shows the five levels for triaging patients with high and low BP. In the first level (normal), the values of high and low BP are 110–130 and 75–85, respectively. In the second level (cold state), the value of High BP is 131–139 or 109–90. The value of low BP is 86–90 or 76–60. In the third level (sick), the value of high BP is 140–159 or 89–60. The value of low BP is 91–99 or 40–59. In the fourth level (urgent), the value of high BP is 160–180 or 50–59. The value of low BP is 100–110 or 33–39. In the fifth level (risk), the value of high BP is higher than 180 or lowest than 50. The value of low BP is higher than 110 or lower than 33.

Employing decision-making solutions to the triage level of each disease is not mathematically applicable because the triage levels for each patient (Tables 3.1 and 3.2) are subjectively diagnosis levels. Thus, data alignment must be designed and applied to convert the subjective diagnosis levels into an integer number. Data alignment designates an integer to each source within each disease. The measurements of BP diseases and CHD are represented by five triage levels, namely, normal, cold state, sick, urgent and at risk, which are replaced by the numbers 0, 1, 2, 3 and 4, respectively (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018).

Thus, the multi-group triage levels vary from patient to another based on emergency cases (as mentioned in Section 2.10), which considers multi-group triage as a practical problem. Thus, rule generation, ordering and expert validation (Steps 2, 3 and of the Phase II) are essential to prioritise patients with MCDs.

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3.4.4 Rule Generation, Ordering and Validation for MCDs

For rule generation, patients with MCDs, such as heart chronic disease and systolic and diastolic diseases are prioritised. Each disease has five triage level probabilities as shown in Figure 3.3.

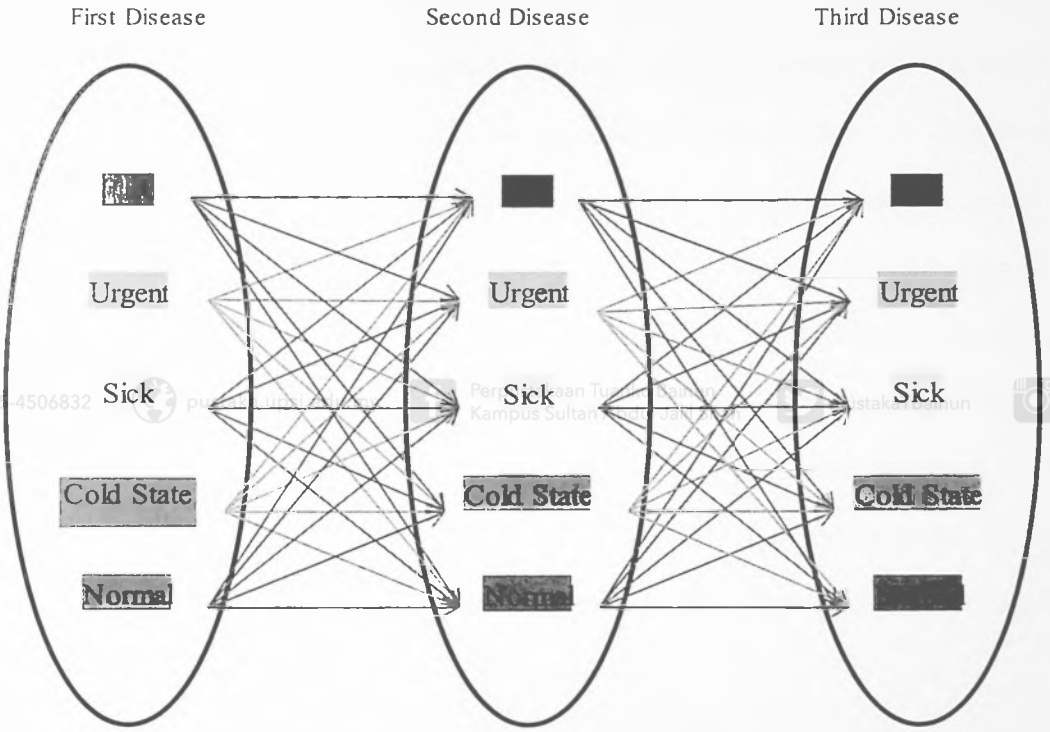


Figure 3.3. The Classification of MCDs by Triage Level

According to 'Step 2: Probabilistic Rule Generation', the probabilistic rules for each patient are obtained as shown in Equation (3.3). Thus, the total probability rules are 125 for each patient.

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For rule ordering, as mentioned in 'Step 3: Rule Ordering', the TROOIL has two scenarios, namely, static and dynamic. For this case study, the second scenario is adopted as a 'proof of concept'. In such scenario, 125 rules from the previous stage are ordered on the basis of their emergency status from the highest (i.e., begins with 'Risk, Risk, Risk') to the lowest emergency case (i.e., ends with 'Normal, Normal, Normal').

For rule validation, medical committee experience is utilised to validate outcomes from rule generation and ordering based on two purposes. The first purpose of rule validation is to present the relative importance of all diseases (i.e., CHDs and high and low BP diseases). Thus, diseases are prioritised and validated in terms of importance for each one. The second purpose is to prioritise the 125 consulted probabilistic rules to ensure that the ranking rules are valid and accurate. The experts within the medical committee use their clinical experience and knowledge. Experts with more than 10 years' experience in the cardiologist disease are selected to show their preferences and judgements (see Section 2 in Table A.2 in Appendix A). This section is considered as a guiding platform for the matching process in the next stage.

3.4.5 Matching in between Triage Patient Level and RuleValidation

In this stage, patients will be organised based on the rule order. The identified triage level for each patient is matched with ranking rules, which is validated by the medical committee. Thus, patient prioritisation is determined according to the sequence of their rules.

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3.4.6 Prioritisation of Patients within Each Rule

In this study, we have 500 patients as alternatives that must be prioritised and a total of 125 rules are presented. Thus, the same rule applies to more than one patient. In such cases, decision matrix is constructed on the basis of crossover 'multi-source for each disease' and 'patients' list within same rule' as shown in Table 3.3.

In this decision-making matrix, the patients represent the alternatives, whereas the multi-source for each disease represents the multi-criteria. Among the four main multi-sources (i.e., ECG, BP, SpO2 and Text) related to CHD, one source for systolic and one for diastolic are used to represent the triage data (Section 4.3.4). In this case, patient prioritisation within same rule is provided accordingly. Then, those patients are ranked based on direct aggregation on the basis of vertical distance normalisation, as mentioned in 'Step 6 in Phase II'. Finally, the set of patients within each rule is ranked according to score in descending order; the highest value indicates that patients should receive the highest priority levels, whereas patients with lowest value should receive low priority levels.

Table 3.3

Decision Matrix

No. P	*CHD*										*Disease High Blood pressure*	*Low Blood pressure Disease*
	Spo2 sensor	Blood pressure sensor	Text features				ECG sensor					
	Spo2	Systolic/ Diastolic	Chest Pain	SH. Breath.	Palip.	rest ?	Peaks	QRS width	P-P	ST El.	HBPD (Systolic)	LBPD (Diastolic)
1												
⋮												
n												

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3.5 Phase VI: Validation and Evaluation

Prioritising patients is a complicated because it is related to patients' lives, in which each patient has several chronic diseases. These diseases have different levels triage that must be evaluated. This research adopts a dataset from a previous study (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018)) conducted from the most reliable and relevant medical database (Goldberger et al., 2000), which has more than 4788 citations (based on July 2017 indexed in Google Scholar) and contains numerous datasets that are already validated and verified by experts.

To achieve the fourth objective, the validation and evaluation of the proposed work must be achieved, as shown in the following subsections. However, the findings of validation and evaluation will be discussed in detail in Chapter 5.

3.5.1 Validation Process

The validation of patient prioritisation results has been done objectively. In this stage, statistical methods (mean ± standard deviation) have been presented to ensure that patient prioritisation undergoes a systematic ranking. The ranking results of the prioritised patients were divided into several groups (as in the studies of (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018)). The ranking result within each set can be divided into several groups, and the alternatives' number within each

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group is varying from group to another on the basis of different cases (Qader et al., 2017). According to the same reference, the number of groups or the alternative number within each group does not affected on the validation result. The results were expressed as mean ± SD for the row data for each group. Mean ($\bar{x}$) is the average and is computed as the sum of all the observed outcomes from the sample divided by the total number presented in Equation (3.12) as follows:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{3.12}$$

Standard deviation (SD) is a measure used to quantify the amount of variation or dispersion of a set of data values, presented in Equation (3.13) as follows:

$$\text{SD} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2} \tag{3.13}$$

Mean ± SD are utilised to ensure that the groups of patients undergo systematic ranking. Each group consists of several patients who are prioritised. Validation is achieved using two methods based on a statistical platform, which should prove that the row data of the first group should reach the highest scoring value by measuring the mean and SD. An example is when the ranking result within same rule is divided into four groups. In this case, to validate the result, the first group should have the highest mean and SD. The mean and SD results of the second group must be lower than or equal to that of the first group and higher or equal to that of the third group. The mean and SD of the third group must be lower than the first and second group or equal to the

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second group and higher or equal to that of the fourth group. Lastly, the mean and SD results of the fourth groups must be lower than the first, second and third group or equal to the third group. According to the systematic ranking results, the first group should be proven statistically to be the highest among other groups. Validation has been presented objectively as presented in Figure 3.2

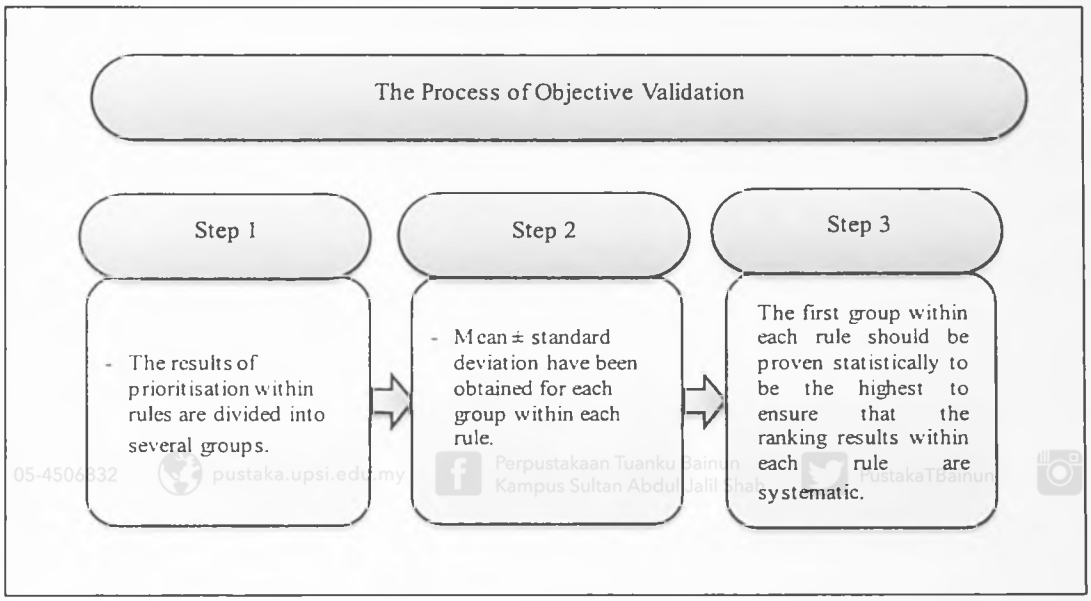


Figure 3.4. Validation Processes

3.5.2 Evaluation Process

As mentioned in Section 2.6.3, the most relevant existing work related to patient prioritisation is in Section 5.3. In this phase, the performance of the proposed work is evaluated and compared with the relevant study.

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Patient prioritisation outside ED has been applied in different environments and further targets different types of patients and diseases. Many issues, such as an aging population, disasters and mass casualty incidents that lead to scalability concerns have been considered in patient prioritisation. Thus, providing scenarios that represent all the considered environments and circumstances in the patient prioritisation area is important.

Each scenario reflects some issues that must be defined and addressed in patient prioritisation methods. Furthermore, these issues are considered as comparison points for comparing the proposed prioritisation method with that of the most relevant existing prioritisation in the checklist with benchmarking (as in the study of (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018)). The comparisons are done on the bases of whether the compared methods covered the issues addressed for each scenario. The scenarios and the comparison points are described in detail in Chapter 5.

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3.6 Chapter Summary

This chapter focused on the research methodology used to achieve the study objectives. The methodology was presented in four phases. These phases propose the structure of our research methodology. Each phase relates to one research objective. First, the preliminary study phase demonstrated a specific analysis for the research problem. Second, the proposed TROOIL is presented to solve the problem of multiple decision-making. Third, prioritisation of patients with MCDs is presented in the third phase, which related to the third objective also described in this chapter. Finally, the fourth phase shows the validation and evaluation of the proposed work. In the next chapter, the results and discussion will be presented in detail.

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CHAPTER 4

RESULTS AND DISCUSSION

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4.1 Introduction

This chapter presents the results prioritising patients with MCDs on the basis of the TROOIL steps. Section 4.2 presents the dataset result of patients with MCDs. Section 4.3 presents the TROOIL result of prioritisation patients with MCDs. Finally, a summary for this chapter is presented in Section 4.4. Figure 4.1 presents the overview of results and evaluation of prioritising patients with MCDs.

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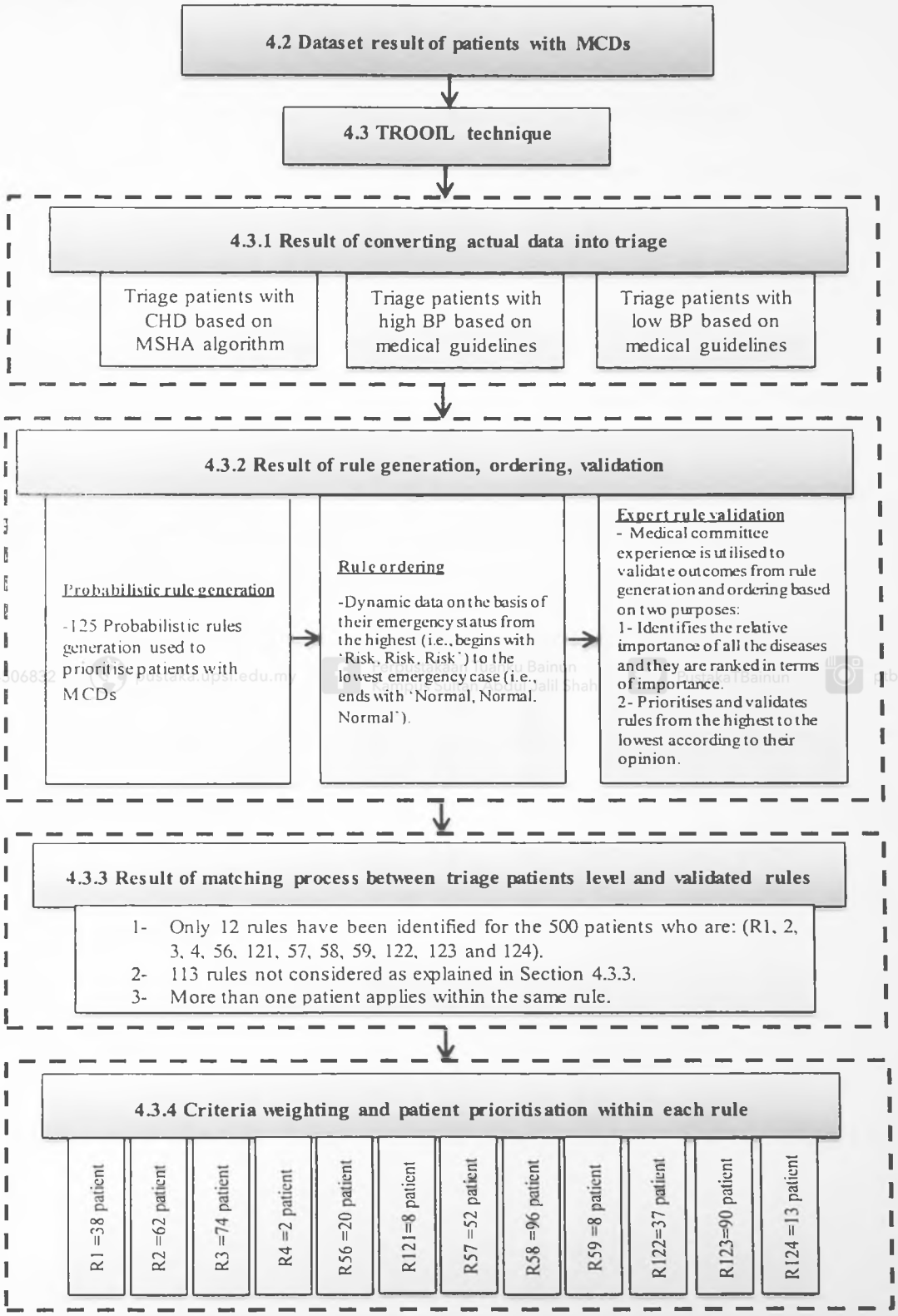


Figure 4.1. Overview of Results and Evaluation of Prioritising Patients with MCDs

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4.2 Dataset Result of Patients with MCDs

The dataset used in this study has been adopted from the prioritisation area over telemedicine as mentioned in Section 3.4.2. In this dataset, three diseases are used as input data in the proposed work. Four important sources are used this dataset. Three of them are sensors, including ECG, SpO2 and BP, and the fourth is text. These sources are utilised to transfer patient status to Tier 3 for evaluation and assessment. A sample of Dataset Result is presented in Table 4.1, whilst the overall result is presented in Table B.1 in Appendix B.

Table 4.1

Sample of the Dataset Presentation Results

p. No.	CHD										High BP Disease	Low BP Disease
	Spo2 sensor	BP sensor	Text features				ECG sensor					
	Spo2	Systolic/ Diastolic	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	ST El.	HBPD (Systolic)	LBPD (Diastolic)
1	97	230/120	false	false	false	false	67	0.06	0.065763	true	230	120
2	97	230/120	false	false	false	true	67	0.06	0.065763	true	230	120
3	97	230/120	false	false	true	false	67	0.06	0.065763	true	230	120
4	97	230/120	false	false	true	true	67	0.06	0.065763	true	230	120
5	97	230/120	false	true	false	false	67	0.06	0.065763	true	230	120
6	97	230/120	false	true	false	true	67	0.06	0.065763	true	230	120
7	97	230/120	false	true	true	false	67	0.06	0.065763	true	230	120
8	97	230/120	false	true	true	true	67	0.06	0.065763	true	230	120
9	97	230/120	true	false	false	false	67	0.06	0.065763	true	230	120
10	97	230/120	true	false	false	true	67	0.06	0.065763	true	230	120
11	97	230/120	true	false	true	false	67	0.06	0.065763	true	230	120
12	97	230/120	true	false	true	true	67	0.06	0.065763	true	230	120
13	97	230/120	true	true	false	false	67	0.06	0.065763	true	230	120
14	97	230/120	true	true	false	true	67	0.06	0.065763	true	230	120
15	97	230/120	true	true	true	false	67	0.06	0.065763	true	230	120
16	97	230/120	true	true	true	true	67	0.06	0.065763	true	230	120
17	92	230/120	false	false	false	false	67	0.06	0.065763	true	230	120
18	92	230/120	false	false	false	true	67	0.06	0.065763	true	230	120
19	92	230/120	false	false	true	false	67	0.06	0.065763	true	230	120
20	92	230/120	false	false	true	true	67	0.06	0.065763	true	230	120
21	92	230/120	false	true	false	false	67	0.06	0.065763	true	230	120
22	92	230/120	false	true	false	true	67	0.06	0.065763	true	230	120
23	92	230/120	false	true	true	false	67	0.06	0.065763	true	230	120
24	92	230/120	false	true	true	true	67	0.06	0.065763	true	230	120
25	92	230/120	true	false	false	false	67	0.06	0.065763	true	230	120
26	92	230/120	true	false	false	true	67	0.06	0.065763	true	230	120
27	92	230/120	true	false	true	false	67	0.06	0.065763	true	230	120

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Table 4.1 *(Continued)*

P. No.	CHD										High BP Disease	Low BP Disease
	Spo2 sensor	BP sensor	Text features				ECG sensor					
	Spo2	Systolic/ Diastolic	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	ST El.	HBPD (Systolic)	LBPD (Diastolic)
28	92	230/120	true	false	true	true	67	0.06	0.065763	true	230	120
29	92	230/120	true	true	false	false	67	0.06	0.065763	true	230	120
30	92	230/120	true	true	false	true	67	0.06	0.065763	true	230	120
31	92	230/120	true	true	true	false	67	0.06	0.065763	true	230	120
32	92	230/120	true	true	true	true	67	0.06	0.065763	true	230	120
33	97	150/100	false	false	false	false	67	0.06	0.065763	true	150	100
34	97	150/100	false	false	false	true	67	0.06	0.065763	true	150	100
35	97	150/100	false	false	true	false	67	0.06	0.065763	true	150	100
36	97	150/100	false	false	true	true	67	0.06	0.065763	true	150	100
37	97	150/100	false	true	false	false	67	0.06	0.065763	true	150	100
38	97	150/100	false	true	false	true	67	0.06	0.065763	true	150	100
39	97	150/100	false	true	true	false	67	0.06	0.065763	true	150	100
40	97	150/100	false	true	true	true	67	0.06	0.065763	true	150	100

Table 4.1 shows dataset samples of 40 patients based on 12 features of MCDs. The next sections will present the prioritisation results of patients with MCDs according to the steps of TROOIL, as mentioned in Sections 3.4.3–3.4.6.

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4.3 TROOIL Result of Prioritisation of Patients with MCDs

This section provides the prioritisation results of patients with MCDs according to the proposed TROOIL. Section 4.3.1 presents the result of converting actual data into triage patients with MCDs. Section 4.3.2 presents the results of rule generation, ordering and validation, which are used to prioritise patients in this research. Section 4.3.3 presents the result of matching between triage patients' level and validated rules. Finally, Section 4.3.4 presents the result of patient prioritisation within each rule.

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4.3.1 Result of Converting Actual Data into Triage Patients with MCDs

In this section, the result of the converting actual patient data into triage patient level has been presented based on two stages as mentioned in Section 3.4.3. In the first stage, MSHA algorithm is one of the most significant algorithms used categorise and triage patients with CHD as mentioned in Section 3.4.3.1. In the second stage, the medical guidelines from the American Heart Association have been used to categorise and triage patients with high and low BP diseases as mentioned in Section 3.4.3.2. The guidelines, which are based on the recommendations of experts from different countries, deal with several diseases, such as high and low BP. The American Heart Association has always worked to produce guidelines aimed to reduce the risk of high and low BP diseases.

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The sample result of triage patients with MCDs based on MSHA algorithm (CHD) and the medical guidelines (high and low BP) is presented in Table 4.2, whilst the overall result of triage patients with MCDs is presented in Table C.1 in Appendix C.

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Table 4.2

Sample of the Result Triage Level

p.no	TCHD	THBPD	TLBPD	p.no	TCHD	THBPD	TLBPD
1	Sick	Risk	Risk	21	Sick	Risk	Risk
2	Sick	Risk	Risk	22	Sick	Risk	Risk
3	Sick	Risk	Risk	23	Urgent	Risk	Risk
4	Sick	Risk	Risk	24	Urgent	Risk	Risk
5	Sick	Risk	Risk	25	Urgent	Risk	Risk
6	Sick	Risk	Risk	26	Urgent	Risk	Risk
7	Sick	Risk	Risk	27	Risk	Risk	Risk
8	Urgent	Risk	Risk	28	Risk	Risk	Risk
9	Sick	Risk	Risk	29	Urgent	Risk	Risk
10	Urgent	Risk	Risk	30	Urgent	Risk	Risk
11	Urgent	Risk	Risk	31	Risk	Risk	Risk
12	Urgent	Risk	Risk	32	Risk	Risk	Risk
13	Urgent	Risk	Risk	33	Sick	Sick	Urgent
14	Urgent	Risk	Risk	34	Sick	Sick	Urgent
15	Risk	Risk	Risk	35	Sick	Sick	Urgent
16	Risk	Risk	Risk	36	Sick	Sick	Urgent
17	Sick	Risk	Risk	37	Sick	Sick	Urgent
18	Sick	Risk	Risk	38	Sick	Sick	Urgent
19	Sick	Risk	Risk	39	Sick	Sick	Urgent
20	Urgent	Risk	Risk	40	Sick	Sick	Urgent

TCHD = Triage ChronicHeart Disease
THBPD = Triage High Blood Pressure Disease
TLBPD = Triage Low Blood Pressure Disease

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Data alignment is designed and applied to convert the subjective diagnosis levels for each patient (in Table 4.2) into integer numbers for each disease, as mentioned in Section 3.4.3. Table 4.3 shows the sample of data alignment for triage levels of patients with MCDs, whilst Table C.2 in Appendix C shows the overall data alignment for the triage levels of MCDs.

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Table 4.3

Sample of the Results Data Alignment Process for Triage Levels of MCDs

p. no.	CHD	HBPD	LBPD	p. no.	CHD	HBPD	LBPD
1	2	4	4	21	2	4	4
2	2	4	4	22	2	4	4
3	2	4	4	23	3	4	4
4	2	4	4	24	3	4	4
5	2	4	4	25	3	4	4
6	2	4	4	26	3	4	4
7	2	4	4	27	4	4	4
8	3	4	4	28	4	4	4
9	2	4	4	29	3	4	4
10	3	4	4	30	3	4	4
11	3	4	4	31	4	4	4
12	3	4	4	32	4	4	4
13	3	4	4	33	2	2	3
14	3	4	4	34	2	2	3
15	4	4	4	35	2	2	3
16	4	4	4	36	2	2	3
17	2	4	4	37	2	2	3
18	2	4	4	38	2	2	3
19	2	4	4	39	2	2	3
20	3	4	4	40	2	2	3

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According to Section 3.4.3, multi-group triage for each patient with MCDs is considered a practical problem of prioritisation. Rule generation, ordering and expert validation steps are provided to avoid this problem, as mentioned in Section 3.4.4. The result will be presented in the next section.

4.3.2 Result of Rule Generation, Ordering and Validation

This section presents the result of rule generation, ordering and validation, which are used to prioritise patients. For rule generation, a total of 125 rules are generated and ordered dynamically from the highest to the lowest emergency case as mentioned in

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Section 3.4.4 In this case, we have three diseases; for each patient, the probability of triage for each disease is ranked into five levels, namely, risk, urgent, sick, cold state and normal. According to Equation (3.3), the total generated rules are 125 for each patient. Table 4.4 shows the result of 125 probabilistic rules used to prioritise patients with MCDs and are ordered dynamically.

Table 4.4

Rule Generation and Ordering Dynamically

Rules	*Disease 1*	*Disease 2*	*Disease 3*	*Rules*	*Disease 1*	*Disease 2*	*Disease 3*
Rule 1	4	4	4	Rule 64	2	2	1
Rule 2	4	4	3	Rule 65	2	2	0
Rule 3	4	4	2	Rule 66	2	1	4
Rule 4	4	4	1	Rule 67	2	1	3
Rule 5	4	4	0	Rule 68	2	1	2
Rule 6	4	3	4	Rule 69	2	1	1
Rule 7	4	3	3	Rule 70	2	1	0
Rule 8	4	3	2	Rule 71	2	0	4
Rule 9	4	3	1	Rule 72	2	0	3
Rule 10	4	3	0	Rule 73	2	0	2
Rule 11	4	2	4	Rule 74	2	0	1
Rule 12	4	2	3	Rule 75	2	0	0
Rule 13	4	2	2	Rule 76	1	4	4
Rule 14	4	2	1	Rule 77	1	4	3
Rule 15	4	2	0	Rule 78	1	4	2
Rule 16	4	1	4	Rule 79	1	4	1
Rule 17	4	1	3	Rule 80	1	4	0
Rule 18	4	1	2	Rule 81	1	3	4
Rule 19	4	1	1	Rule 82	1	3	3
Rule 20	4	1	0	Rule 83	1	3	2
Rule 21	4	0	4	Rule 84	1	3	1
Rule 22	4	0	3	Rule 85	1	3	0
Rule 23	4	0	2	Rule 86	1	2	4
Rule 24	4	0	1	Rule 87	1	2	3
Rule 25	4	0	0	Rule 88	1	2	2
Rule 26	3	4	4	Rule 89	1	2	1
Rule 27	3	4	3	Rule 90	1	2	0
Rule 28	3	4	2	Rule 91	1	1	4
Rule 29	3	4	1	Rule 22	1	1	3
Rule 30	3	4	0	Rule 93	1	1	2
Rule 31	3	3	4	Rule 94	1	1	1
Rule 32	3	3	3	Rule 95	1	1	0
Rule 33	3	3	2	Rule 96	1	0	4
Rule 34	3	3	1	Rule 97	1	0	3
Rule 35	3	3	0	Rule 98	1	0	2
Rule 36	3	2	4	Rule 99	1	0	1
Rule 37	3	2	3	Rule 100	1	0	0
Rule 38	3	2	2	Rule 101	0	4	4
Rule 39	3	2	1	Rule 102	0	4	3
Rule 40	3	2	0	Rule 103	0	4	2
Rule 41	3	1	4	Rule 104	0	4	1
Rule 42	3	1	3	Rule 105	0	4	0
Rule 43	3	1	2	Rule 106	0	3	4
Rule 44	3	1	1	Rule 107	0	3	3
Rule 45	3	1	0	Rule 108	0	3	2
Rule 46	3	0	4	Rule 109	0	3	1
Rule 47	3	0	3	Rule 110	0	3	0

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Table 4.4 *(Continued)*

Rules	*Disease 1*	*Disease 2*	*Disease 3*	*Rules*	*Disease 1*	*Disease 2*	*Disease 3*
Rule 48	3	0	2	Rule 111	0	2	4
Rule 49	3	0	1	Rule 112	0	2	3
Rule 50	3	0	0	Rule 113	0	2	2
Rule 51	2	4	4	Rule 114	0	2	1
Rule 52	2	4	3	Rule 115	0	2	0
Rule 53	2	4	2	Rule 116	0	1	4
Rule 54	2	4	1	Rule 117	0	1	3
Rule 55	2	4	0	Rule 118	0	1	2
Rule 56	2	3	4	Rule 119	0	1	1
Rule 57	2	3	3	Rule 120	0	1	0
Rule 58	2	3	2	Rule 121	0	0	4
Rule 59	2	3	1	Rule 122	0	0	3
Rule 60	2	3	0	Rule 123	0	0	2
Rule 61	2	2	4	Rule 124	0	0	1
Rule 62	2	2	3	Rule 125	0	0	0
Rule 63	2	2	2				

4 = Risk
3 = Urgent
2 = Sick
1 = Cold State
0 = Normal

Table 4.4 shows the 125 rules for patients with three diseases, including disease 1, disease 2 and disease 3. The rules are prioritised from the highest (i.e., begins with 'Risk, Risk, and Risk') to the lowest emergency cases (i.e., ends with 'Normal, Normal, and Normal'). In this stage, three diseases are not prioritised yet because the importance of each disease is unknown and should be identified and determined by the medical committee, as mentioned in Section 3.4.4.

For rule validation, the result of rule generation and ordering has been sent to the medical committee for two purposes as mentioned in Section 3.4.4. In the first step, the medical committee identifies the relative importance of all the diseases, and they are ranked in terms of importance. Then, the medical committee prioritises and validates rules from the highest to the lowest according to their opinion. The results of relative importance of the three diseases and rule validation from the medical committee are presented in Table 4.5.

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Table 4.5

Rule Ranking based on Medical Committee Perspectives

Rules	*HBPD*	*LBPD*	*CHD*	*Ranking by medical committee perspectives*	*Rules*	*HBPD*	*LBPD*	*CHD*	*Ranking by medical committee perspectives*
Rule 1	4	4	4	1	Rule 64	2	2	1	100
Rule 2	4	4	3	2	Rule 65	2	2	0	101
Rule 3	4	4	2	5	Rule 66	2	1	4	54
Rule 4	4	4	1	11	Rule 67	2	1	3	55
Rule 5	4	4	0	21	Rule 68	2	1	2	83
Rule 6	4	3	4	3	Rule 69	2	1	1	84
Rule 7	4	3	3	8	Rule 70	2	1	0	102
Rule 8	4	3	2	14	Rule 71	2	0	4	103
Rule 9	4	3	1	24	Rule 72	2	0	3	106
Rule 10	4	3	0	25	Rule 73	2	0	2	108
Rule 11	4	2	4	6	Rule 74	2	0	1	107
Rule 12	4	2	3	16	Rule 75	2	0	0	109
Rule 13	4	2	2	30	Rule 76	1	4	4	13
Rule 14	4	2	1	31	Rule 77	1	4	3	28
Rule 15	4	2	0	32	Rule 78	1	4	2	44
Rule 16	4	1	4	12	Rule 79	1	4	1	46
Rule 17	4	1	3	22	Rule 80	1	4	0	47
Rule 18	4	1	2	27	Rule 81	1	3	4	52
Rule 19	4	1	1	29	Rule 82	1	3	3	70
Rule 20	4	1	0	33	Rule 83	1	3	2	80
Rule 21	4	0	4	34	Rule 84	1	3	1	91
Rule 22	4	0	3	35	Rule 85	1	3	0	92
Rule 23	4	0	2	37	Rule 86	1	2	4	57
Rule 24	4	0	1	36	Rule 87	1	2	3	85
Rule 25	4	0	0	38	Rule 88	1	2	2	104
Rule 26	3	4	4	4	Rule 89	1	2	1	110
Rule 27	3	4	3	9	Rule 90	1	2	0	111
Rule 28	3	4	2	15	Rule 91	1	1	4	59
Rule 29	3	4	1	39	Rule 92	1	1	3	95
Rule 30	3	4	0	26	Rule 93	1	1	2	114
Rule 31	3	3	4	10	Rule 94	1	1	1	118
Rule 32	3	3	3	20	Rule 95	1	1	0	119
Rule 33	3	3	2	63	Rule 96	1	0	4	60
Rule 34	3	3	1	64	Rule 97	1	0	3	96
Rule 35	3	3	0	65	Rule 98	1	0	2	115
Rule 36	3	2	4	18	Rule 99	1	0	1	120
Rule 37	3	2	3	66	Rule 100	1	0	0	122
Rule 38	3	2	2	72	Rule 101	0	4	4	23
Rule 39	3	2	1	73	Rule 102	0	4	3	40
Rule 40	3	2	0	74	Rule 103	0	4	2	45
Rule 41	3	1	4	50	Rule 104	0	4	1	48
Rule 42	3	1	3	51	Rule 105	0	4	0	49
Rule 43	3	1	2	67	Rule 106	0	3	4	53
Rule 44	3	1	1	68	Rule 107	0	3	3	71
Rule 45	3	1	0	75	Rule 108	0	3	2	81
Rule 46	3	0	4	76	Rule 109	0	3	1	93
Rule 47	3	0	3	87	Rule 110	0	3	0	94
Rule 48	3	0	2	89	Rule 111	0	2	4	58
Rule 49	3	0	1	88	Rule 112	0	2	3	86
Rule 50	3	0	0	90	Rule 113	0	2	2	105
Rule 51	2	4	4	7	Rule 114	0	2	1	112
Rule 52	2	4	3	17	Rule 115	0	2	0	113
Rule 53	2	4	2	43	Rule 116	0	1	4	61
Rule 54	2	4	1	41	Rule 117	0	1	3	97
Rule 55	2	4	0	42	Rule 118	0	1	2	116
Rule 56	2	3	4	19	Rule 119	0	1	1	121
Rule 57	2	3	3	69	Rule 120	0	1	0	123
Rule 58	2	3	2	77	Rule 121	0	0	4	62
Rule 59	2	3	1	78	Rule 122	0	0	3	98
Rule 60	2	3	0	79	Rule 123	0	0	2	117
Rule 61	2	2	4	56	Rule 124	0	0	1	124

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Table 4.5 *(Continued)*

Rules	*HBPD*	*LBPD*	*CHD*	*Ranking by medical committee perspectives*	*Rules*	*HBPD*	*LBPD*	*CHD*	*Ranking by medical committee perspectives*
Rule 62	2	2	3	82	Rule 125	0	0	0	125
Rule 63	2	2	2	99					

Table 4.5 shows the result of ranking based on the medical committee perspectives, which assigned the maximum importance for high BP, low BP and CHD. The table is considered as guiding platform for the matching process, as mentioned in Section 3.4.4. The result that supports the matching process will be presented in the next section.

4.3.3 Result of matching process between triage patients level and validated rules

In this stage, the result of triage patients' level from Section 4.3.1 has been matched with corresponding rules validated from the medical committee in Section 4.3.2, as mentioned in Section 3.4.5. A sample of the results of matching between each patient triage with corresponding rule is presented in Table 4.6, whereas the overall matching process is presented in Table D.1 in Appendix D.

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Table 4.6

Sample Result of Matching between Each Patient Triage and Validated Rules

P. No.	HBPD	LBPD	CHD	Rules	P. No.	HBPD	LBPD	CHD	Rules
1	4	4	2	R3	21	4	4	2	R3
2	4	4	2	R3	22	4	4	2	R3
3	4	4	2	R3	23	4	4	3	R2
4	4	4	2	R3	24	4	4	3	R2
5	4	4	2	R3	25	4	4	3	R2
6	4	4	2	R3	26	4	4	3	R2
7	4	4	2	R3	27	4	4	4	R1
8	4	4	3	R2	28	4	4	4	R1
9	4	4	2	R3	29	4	4	3	R2
10	4	4	3	R2	30	4	4	3	R2
11	4	4	3	R2	31	4	4	4	R1
12	4	4	3	R2	32	4	4	4	R1
13	4	4	3	R2	33	2	3	2	R58
14	4	4	3	R2	34	2	3	2	R58
15	4	4	4	R1	35	2	3	2	R58
16	4	4	4	R1	36	2	3	2	R58
17	4	4	2	R3	37	2	3	2	R58
18	4	4	2	R3	38	2	3	2	R58
19	4	4	2	R3	39	2	3	2	R58
20	4	4	3	R2	40	2	3	2	R58

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Tables 4.6 and D.1 show 500 patients and their triage levels, which match with validated rules to identify patient prioritisation. Patient prioritisation has been determined according to the sequence of their rules. As shown in Tables 4.6 and D.1, only 12 rules have been identified for the 500 patients, while 113 rules not considered because of there are no patients matched with these rules. Thus, more than one patient applies within the same rule. The result of the matching process resulted in 38, 62, 74, 2, 20, 8, 52, 96, 8, 37, 90 and 13 patients within rules 1, 2, 3, 4, 56, 121, 57, 58, 59, 122, 123 and 124, respectively. Prioritisation for patients within the same rule will be described in the next section.

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4.3.4 Criteria weighting and Patient Prioritisation within Each Rule

In this stage, criteria weighting of each rule has been done objectively, and patients with MCDs within each rule have been prioritised by DM solutions through direct aggregation (Section 3.4.6). Decision matrix is created based on crossover of 'multi-source for each disease' and 'patient' list within the same rule'. Ten features related to CHD, one feature for systolic BP and one feature for diastolic BP have been utilised in the decision matrix to prioritise patients at this stage. All of these features are considered as beneficial criteria in decision making. Table 4.7 shows that the decision matrix for patients within rule 1 with their triage data, whilst the decision matrices for others rules are presented in Tables E.1, E.2, E.3, E.4, E.5, E.6, E.7, E.8, E.9, E.10 and E.11 of Appendix E show that the decision matrix for patients within rules 2, 3, 4, 56, 121, 57, 58, 59, 122, 123 and 124, respectively.

Table 4.7

Decision Matrix for Patients within Rule 1

P. No.	*HBPD*	*LBPD*	*Spo2*	*BP*	*Chest Pain*	*SH. Breath.*	*Palip.*	*rest?*	*Peaks*	*QRS width*	*P-P*	*ST El.*
15	4	4	0	4	1	1	1	0	0	0	0	0
16	4	4	0	4	1	1	1	1	0	0	0	0
27	4	4	1	4	1	0	1	0	0	0	0	0
28	4	4	1	4	1	0	1	1	0	0	0	0
31	4	4	1	4	1	1	1	0	0	0	0	0
32	4	4	1	4	1	1	1	1	0	0	0	0
139	4	4	2	4	1	0	1	0	0	0	0	0
140	4	4	2	4	1	0	1	1	0	0	0	0
141	4	4	2	4	1	1	0	0	0	0	0	0
142	4	4	2	4	1	1	0	1	0	0	0	0
143	4	4	2	4	1	1	1	0	0	0	0	0
144	4	4	2	4	1	1	1	1	0	0	0	0
175	4	4	1	4	1	1	1	0	1	1	0	1
176	4	4	1	4	1	1	1	1	1	1	0	1
283	4	4	2	4	1	0	1	0	1	1	0	1

(Continue)

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Table 4.7 *(Continued)*

P. No.	*HBPD*	*LBPD*	*Spo2*	*BP*	*Chest Pain*	*SII. Breath.*	*Palip.*	*rest?*	*Peaks*	*QRS width*	*P-P*	*ST El.*
284	4	4	2	4	1	0	1	1	1	1	0	1
287	4	4	2	4	1	1	1	0	1	1	0	1
288	4	4	2	4	1	1	1	1	1	1	0	1
299	4	4	0	4	1	0	1	0	0	0	1	0
300	4	4	0	4	1	0	1	1	0	0	1	0
303	4	4	0	4	1	1	1	0	0	0	1	0
304	4	4	0	4	1	1	1	1	0	0	1	0
315	4	4	1	4	1	0	1	0	0	0	1	0
316	4	4	1	4	1	0	1	1	0	0	1	0
317	4	4	1	4	1	1	0	0	0	0	1	0
318	4	4	1	4	1	1	0	1	0	0	1	0
319	4	4	1	4	1	1	1	0	0	0	1	0
320	4	4	1	4	1	1	1	1	0	0	1	0
423	4	4	2	4	0	1	1	0	0	0	1	0
424	4	4	2	4	0	1	1	1	0	0	1	0
425	4	4	2	4	1	0	0	0	0	0	1	0
426	4	4	2	4	1	0	0	1	0	0	1	0
427	4	4	2	4	1	0	1	0	0	0	1	0
428	4	4	2	4	1	0	1	1	0	0	1	0
429	4	4	2	4	1	1	0	0	0	0	1	0
430	4	4	2	4	1	1	0	1	0	0	1	0
431	4	4	2	4	1	1	1	0	0	0	1	0
432	4	4	2	4	1	1	1	1	0	0	1	0

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Criteria weighting and ranking patients within rule 1 are performed by normalisation using Equation (3.6) (Table 4.8).

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Table 4.8

Normalised Decision Matrix for Patients within Rule 1

P. No.	*HBPD*	*LBPD*	*Spo2*	*BP*	*Chest Pain*	*SII. Breath.*	*Palip.*	*rest?*	*Peaks*	*QRS width*	*P-P*	*ST El.*
15	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000
16	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000
27	1.000	1.000	0.500	1.000	1.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000
28	1.000	1.000	0.500	1.000	1.000	0.000	1.000	1.000	0.000	0.000	0.000	0.000
31	1.000	1.000	0.500	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000
32	1.000	1.000	0.500	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000
139	1.000	1.000	1.000	1.000	1.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000
140	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.000	0.000	0.000	0.000
141	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
142	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	0.000	0.000	0.000	0.000
143	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000
144	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000
175	1.000	1.000	0.500	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.000	1.000
176	1.000	1.000	0.500	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000
283	1.000	1.000	1.000	1.000	1.000	0.000	1.000	0.000	1.000	1.000	0.000	1.000
284	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	1.000
287	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.000	1.000
288	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000
299	1.000	1.000	0.000	1.000	1.000	0.000	1.000	0.000	0.000	0.000	1.000	0.000
300	1.000	1.000	0.000	1.000	1.000	0.000	1.000	1.000	0.000	0.000	1.000	0.000
303	1.000	1.000	0.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	1.000	0.000
304	1.000	1.000	0.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	1.000	0.000
315	1.000	1.000	0.500	1.000	1.000	0.000	1.000	0.000	0.000	0.000	1.000	0.000
316	1.000	1.000	0.500	1.000	1.000	0.000	1.000	1.000	0.000	0.000	1.000	0.000
317	1.000	1.000	0.500	1.000	1.000	1.000	0.000	0.000	0.000	0.000	1.000	0.000
318	1.000	1.000	0.500	1.000	1.000	1.000	0.000	1.000	0.000	0.000	1.000	0.000
319	1.000	1.000	0.500	1.000	1.000	1.000	1.000	0.000	0.000	0.000	1.000	0.000
320	1.000	1.000	0.500	1.000	1.000	1.000	1.000	1.000	0.000	0.000	1.000	0.000
423	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.000	0.000	0.000	1.000	0.000
424	1.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	0.000	0.000	1.000	0.000
425	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000
426	1.000	1.000	1.000	1.000	1.000	0.000	0.000	1.000	0.000	0.000	1.000	0.000
427	1.000	1.000	1.000	1.000	1.000	0.000	1.000	0.000	0.000	0.000	1.000	0.000
428	1.000	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.000	0.000	1.000	0.000
429	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.000	1.000	0.000
430	1.000	1.000	1.000	1.000	1.000	1.000	0.000	1.000	0.000	0.000	1.000	0.000
431	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	1.000	0.000
432	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	1.000	0.000

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The same processes have been conducted to normalise patients within other rules. Then, the entropy values and weights are calculated for each criterion by using Equations (3.8) and (3.9).

Table 4.9

Entropy Values and Weights for Each Criterion for Each Rule

Rules/Criteria		HBPD	LBPD	Spo2	BP	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	ST EL
Rule 1	Entropy values (ej)	1.000	1.000	0.940	1.000	0.985	0.874	0.935	0.809	0.493	0.493	0.824	0.493
	Entropy weights (wj)	0.000	0.000	0.028	0.000	0.007	0.059	0.030	0.088	0.235	0.235	0.082	0.235
Rule 2	Entropy values (ej)	1.000	1.000	0.891	1.000	0.888	0.847	0.861	0.868	0.700	0.700	0.770	0.789
	Entropy weights (wj)	0.000	0.000	0.065	0.000	0.067	0.091	0.082	0.078	0.178	0.178	0.137	0.125
Rule 3	Entropy values (ej)	1.000	1.000	0.832	1.000	0.596	0.798	0.728	0.805	0.738	0.738	0.819	0.890
	Entropy weights (wj)	0.000	0.000	0.082	0.000	0.197	0.098	0.132	0.095	0.127	0.127	0.088	0.054
Rule 4	Entropy values (ej)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.011	1.000	1.000	1.000	1.000
	Entropy weights (wj)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
Rule 56	Entropy values (ej)	1.000	1.000	0.950	1.000	1.000	0.881	0.965	0.769	0.231	0.231	0.829	0.231
	Entropy weights (wj)	0.000	0.000	0.017	0.000	0.000	0.041	0.012	0.079	0.264	0.264	0.059	0.264
Rule 121	Entropy values (ej)	1.000	1.000	0.983	1.000	1.000	0.863	1.000	0.670	1.000	1.000	0.863	1.000
	Entropy weights (wj)	0.000	0.000	0.027	0.000	0.000	0.221	0.000	0.531	0.000	0.000	0.221	0.000
Rule 57	Entropy values (ej)	1.000	1.000	0.913	1.000	0.940	0.852	0.877	0.869	0.668	0.668	0.758	0.732
	Entropy weights (wj)	0.000	0.000	0.051	0.000	0.035	0.086	0.071	0.076	0.193	0.193	0.140	0.156
Rule 58	Entropy values (ej)	1.000	1.000	0.857	0.995	0.722	0.824	0.797	0.824	0.745	0.745	0.819	0.866
	Entropy weights (wj)	0.000	0.000	0.079	0.003	0.154	0.097	0.112	0.097	0.141	0.141	0.100	0.074
Rule 59	Entropy values (ej)	1.000	1.000	0.333	1.000	1.000	0.333	1.000	0.667	0.333	0.333	0.862	1.000
	Entropy weights (wj)	0.000	0.000	0.212	0.000	0.000	0.212	0.000	0.106	0.212	0.212	0.044	0.000
Rule 122	Entropy values (ej)	1.000	1.000	0.918	1.000	0.977	0.856	0.902	0.856	0.608	0.608	0.731	0.608
	Entropy weights (wj)	0.000	0.000	0.042	0.000	0.012	0.074	0.051	0.074	0.202	0.202	0.139	0.202
Rule 123	Entropy values (ej)	1.000	1.000	0.885	1.000	0.756	0.831	0.808	0.836	0.777	0.777	0.732	0.777
	Entropy weights (wj)	0.000	0.000	0.063	0.000	0.134	0.093	0.105	0.090	0.122	0.122	0.147	0.122
Rule 124	Entropy values (ej)	1.000	1.000	0.270	1.000	1.000	0.270	0.270	0.699	0.699	0.699	0.627	0.898
	Entropy weights (wj)	0.000	0.000	0.205	0.000	0.000	0.205	0.205	0.084	0.084	0.084	0.104	0.029

Table 4.9 shows the entropy values and entropy weights determined for each criterion for all rules. Entropy information of some criteria for all rules except rule 57 is the maximum value (1) because f_{ij} for these criteria is the same for all patients. This process leads to the 0 entropy weight for these criteria as described in Step 6 in

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Section 3.3. According to the same table, the criteria with highest entropy weight are considered the most important criteria, whilst the criteria with lowest entropy weight are less important.

Patients within each rule have been prioritised based on these weights. The results of the DM solution for patients' within rule 1 are presented in Table 4.10, whilst Tables F.1, F.2, F.3, F.4, F.5, F.6, F.7, F.8, F.9, F.10 and F.11 of Appendix F show the ranking results for patient prioritisation within rules 2, 3, 4, 56, 121, 57, 58, 59, 122, 123 and 124, respectively.

Table 4.10

Patient Prioritisation within Rule 1

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 15	0.008	35	Patient 300	0.017	16
Patient 16	0.015	22	Patient 303	0.015	24
Patient 27	0.004	38	Patient 304	0.022	10
Patient 28	0.012	29	Patient 315	0.011	30
Patient 31	0.009	34	Patient 316	0.018	14
Patient 32	0.017	20	Patient 317	0.013	26
Patient 139	0.005	37	Patient 318	0.021	12
Patient 140	0.013	27	Patient 319	0.016	21
Patient 141	0.008	36	Patient 320	0.023	9
Patient 142	0.015	23	Patient 423	0.017	19
Patient 143	0.010	31	Patient 424	0.024	8
Patient 144	0.018	15	Patient 425	0.010	33
Patient 175	0.068	5	Patient 426	0.017	18
Patient 176	0.075	2	Patient 427	0.012	28
Patient 283	0.064	6	Patient 428	0.020	13
Patient 284	0.072	3	Patient 429	0.015	25
Patient 287	0.069	4	Patient 430	0.022	11
Patient 288	0.077	1	Patient 431	0.017	17
Patient 299	0.010	32	Patient 432	0.024	7

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Table 4.10 and Appendix F show the results of patient prioritisation within each rule. The set of patients within each rule has been ranked in descending order in accordance with scores as mentioned in Section 3.4.6. The highest value indicates that patients received the highest priority levels, but patients with the lowest value received low priority levels. Patients with the most severe cases of MCDs can be treated first on the basis of their highest priority levels. The treatment for patients with less severe cases can be delayed more than that of others. Finally, the effectivity of TROOIL to rapidly determine the prioritisation of patients with MCDs on the basis of various triage levels has been proven.

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4.4 Chapter Summary

The results in this chapter represent the second and third phases of the work. The result of the dataset of patients with MCDs is presented. This chapter provides TROOIL result of prioritisation of patients with MCDs, which is the main finding of this chapter. As a first stage of prioritisation, MSHA algorithm and the medical guidelines are presented to provide the result of the triage patients with MCDs. Data alignment result is presented to convert the subjective diagnosis levels for each patient into an integer number for each disease. Considering the results of rule generation, dynamic ordering and rule validation from the medical committee are also presented to in prioritisation. The results of matching between each patient triage with corresponding rules are presented to identify the priority for each patient. At the final stage, in case of more than one patient with the same rule, patients with MCDs have been prioritised and presented through decision-making solution-based direct aggregation. Thus, validating and evaluating the provided results are necessary in the following chapter.

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CHAPTER 5

VALIDATION AND EVALUATION

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5.1 Introduction

This chapter describes in detail the validation and evaluation of the proposed prioritisation of MCDs. Validation is presented in Section 5.2, and the ranking results for each rule have been validated objectively. Section 5.3 demonstrates the evaluation via scenarios and checklist benchmarking. Finally, a summary for this chapter is presented in Section 5.4.

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5.2 Validation Process

Validation is an important measure for many of empirical research to prove result validity and accuracy. Validation has been presented objectively as presented in Figure 5.1

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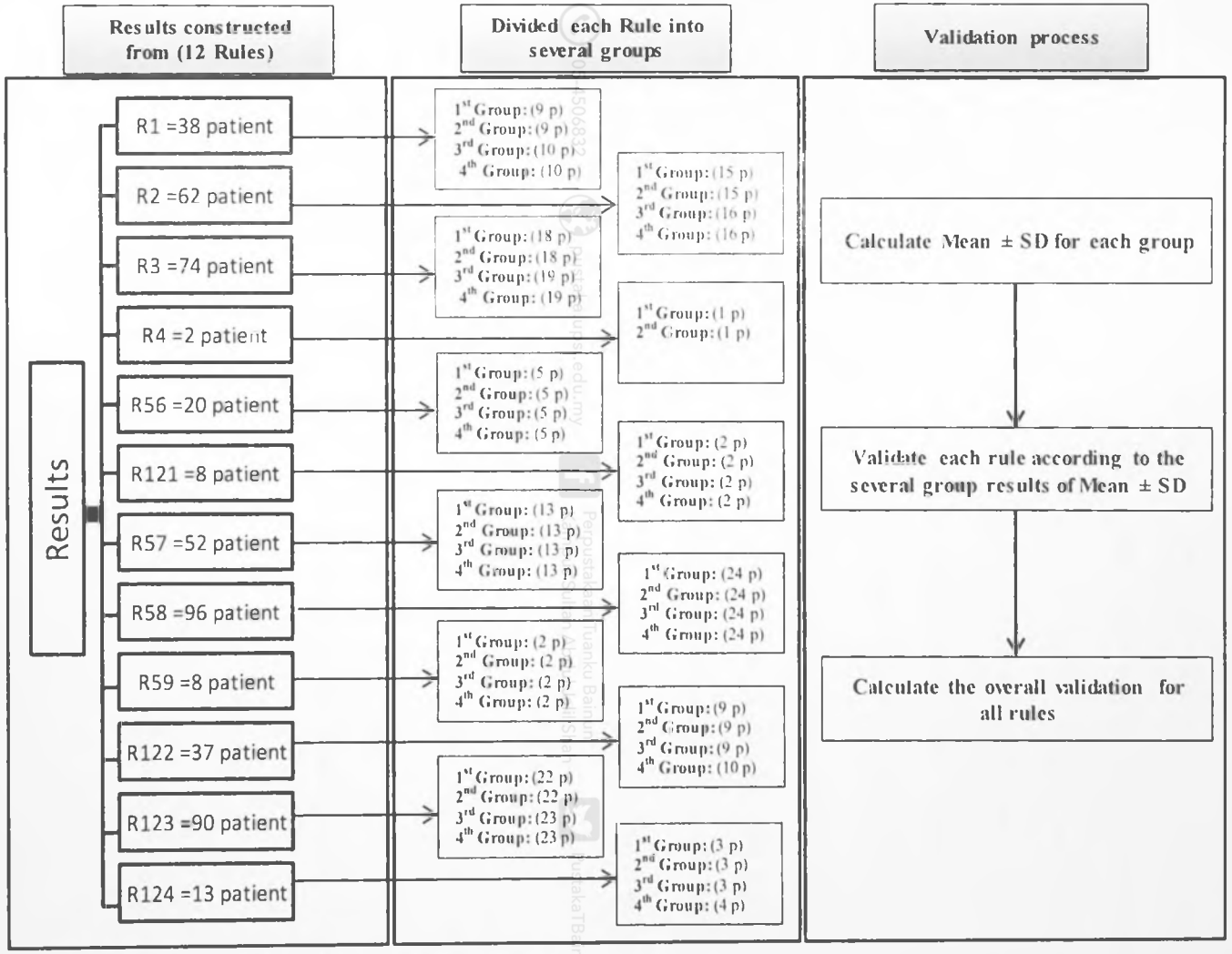


Figure 5.1. Structure of the Validation Processes

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In this stage, the final ranking results of the prioritised patients within rules 1, 2, 3, 56, 121, 57, 58, 59, 122, 123 and 124 are divided into four equal groups. The final ranking results of the prioritised patients within rule 4 are divided into two equal groups. The first and second groups for rule 1 include 9 patients, and third and fourth groups include 10 patients. The first and second groups in rule 2 include 15 patients, and the third and fourth groups include 16 patients. The first and second groups in rule 3 have 18 patients, and the third and fourth groups have 19 patients. The first and second groups in rule 4 include one patient. Each group for rules 56, 121, 57, 58 and 59 includes 5, 2, 13, 24 and 2 patients, respectively. The first, second and third groups in rule 122 have 9 patients, and the fourth group has 10 patients. The first and second groups in rule 123 have 22 patients, and the third and fourth groups have 23 patients. The first, second and third groups for rule 124 have three patients, and the fourth group has four patients.

Finally, mean ± SD have been calculated for each group within each rule to ensure that the prioritised patients have a systematic ranking, as mentioned in Section 3.5.1. The results of the statistical analysis for prioritisation within all rules are presented in Table 5.1.

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Table 5.1

Statistical Analysis Results for Patient Prioritisation within all Rules

Prioritization patients' within all rules		*1st group*	*2nd group*	*3th group*	*4th group*
Rule 1	*Mean* ($\bar{x}$)	0.055	0.019	0.015	0.009
	Standard deviation (SD)	0.085	0.031	0.027	0.019
Rule 2	*Mean* ($\bar{x}$)	0.061	0.043	0.024	0.015
	Standard deviation (SD)	0.067	0.055	0.041	0.031
Rule 3	*Mean* ($\bar{x}$)	0.045	0.035	0.023	0.011
	Standard deviation (SD)	0.057	0.053	0.042	0.031
Rule 4	*Mean* ($\bar{x}$)	0.083	0.0001	/	/
	Standard deviation (SD)	0.289	0.000	/	/
Rule 56	*Mean* ($\bar{x}$)	0.040	0.013	0.010	0.005
	Standard deviation (SD)	0.079	0.025	0.020	0.013
Rule 121	*Mean* ($\bar{x}$)	0.083	0.065	0.039	0.021
	Standard deviation (SD)	0.161	0.156	0.084	0.062
Rule 57	*Mean* ($\bar{x}$)	0.063	0.037	0.021	0.014
	Standard deviation (SD)	0.074	0.052	0.038	0.027
Rule 58	*Mean* ($\bar{x}$)	0.050	0.038	0.025	0.013
	Standard deviation (SD)	0.059	0.052	0.044	0.033
Rule 59	*Mean* ($\bar{x}$)	0.040	0.030	0.021	0.008
	Standard deviation (SD)	0.082	0.064	0.060	0.024
Rule 122	*Mean* ($\bar{x}$)	0.066	0.026	0.019	0.012
	Standard deviation (SD)	0.083	0.043	0.036	0.023
Rule 123	*Mean* ($\bar{x}$)	0.053	0.038	0.024	0.014
	Standard deviation (SD)	0.057	0.054	0.046	0.035
Rule 124	*Mean* ($\bar{x}$)	0.039	0.032	0.019	0.007
	Standard deviation (SD)	0.062	0.061	0.035	0.024

In Table 5.1, statistical analysis is presented for each group per rule. The comparison indicates that the first group scores the highest and is the best in terms of ranking results within all rules. The scores of the second, third and fourth groups follow the first group's scores. Thus, the first group is the best in terms of ranking results within all rules. The statistical results indicate that prioritisation of patients with MCDs has a systematic ranking.

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5.3 Evaluation Process

In this section, evaluation is presented to demonstrate the performance of this work. The proposed prioritisation has been compared with the most relevant study in the research area considering specific issues as mentioned in Section 3.5.2. To demonstrate the comparison points and issues in the checklist benchmarking, four scenarios are illustrated as follows.

In the first scenario, comparison between the proposed and benchmark work is based on the case studies and related issues. Ideally, in medical research, case studies should detail a particular medical case (disease), describing the background of the patient and related issues. Investigations undertaken must be discussed to determine a diagnosis or differentiate between possible diagnoses (O. H. Salman, Zaidan, Zaidan, Naserkalid, & Hashim, 2017). As a whole, case studies should be an informative and useful part of every medical research. For each disease, the real-time remote monitoring of patients who live far from hospitals is an important and essential factor (Baig & Gholamhosseini, 2013; Okura et al., 2016). In patient monitoring, medical sensors are utilised to measure vital signs and in triage and prioritisation (Kateretse, Lee, & Huh, 2013). Vital signs are useful in monitoring and measuring the vital signs and plays a vital role in healthcare monitoring (Rocha, Martins, Freire Junior, et al., 2013). Text data (i.e., complaints) can be used as another medical source to improve the accuracy of diagnosis (O. H. Salman et al., 2014).

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In the second scenario, compression has been done on the large scale of patient procedure and related issues, which are expected to occur in several aspects, namely, population ageing, disasters and MCIs and have been reported in a specific area. This area has a large population of elderly patients who are remotely monitored by their providers. From another perspective, the remote patients are critically affected by MCIs and disasters (Wyte-Lake et al., 2016). The server of a hospital or healthcare agency that monitors those patients has to assess the situation of the patients and prioritise them for services and treatments according to the urgency of their medical condition. However, for remote patients, the overwhelming huge heterogeneous data could cause difficulty in making decisions as to whom the care should be given first and then onwards when numerous patients are involved (Sarkar & Sinha, 2014). Therefore, prioritisation should support a multi criteria ranking with considering scalability issue with ability to handle data variation, and different weights are often given for the attributes in patient prioritisation (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018). Furthermore, identifying the targeted tier and the environment, where prioritisation has been executed is needed to prioritise patients with the most to least emergency case to provide services and treatments for each.

In the third scenario, compression has been done on patient prioritisation procedure and related issues. Two or more home patients with a slight difference in their healthcare emergency conditions must be prioritised. In this case, the healthcare providers face a problem in terms of recognising the slight difference in patient vital signs, regardless of the time needed to prioritise patients. Traditional prioritisation

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allocates such patients in the same scale or category (David Claudio et al., 2014). Therefore, the prioritization method should take into consideration the smallest difference between the two patient records and improve the patient prioritization accuracy. Thus, there is a need to provide patient order through supporting expert opinion and multi criteria ranking.

In the fourth scenario, compression has been done on the basis of validation and evaluation of both works. Validation is the process of checking whether or not a proposed work is valid, and appropriate for its purpose, meets all constraints and will perform as expected (Minutolo et al., 2015). Evaluation is the process of comparing and computing performance and accuracy of the proposed work ("Evaluation of Miniature Wireless Vital Signs Monitor in a Trauma Intensive Care Unit," 2016).

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After describing the comparison scenarios, some issues have been recognised and highlighted for each scenario and must be further considered in the prioritisation work of patients with MCDs. These issues have been extracted, and the connections between each scenario and the related points are described in Figure 5.2.

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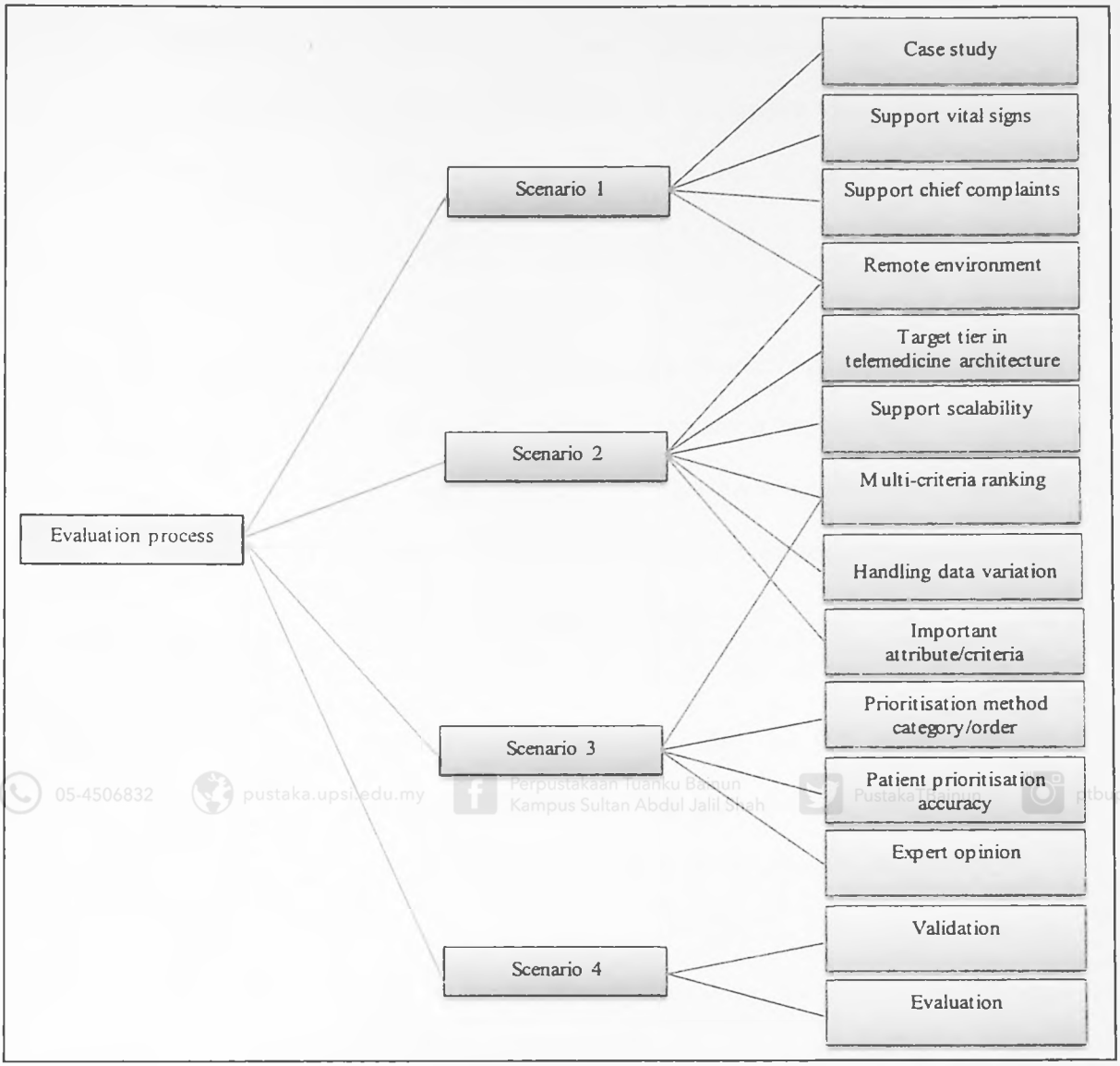


Figure 5.2. Relationship between the Comparison Issues and Scenarios

These issues are defined to be considered as comparison points in the checklist benchmarking. The terms descriptions of the checklist comparison points are presented as follows:

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- **MCDs:** Targeting MCDs as a case study for applying and testing patient prioritisation is helpful in identifying and recognising the vital signs and complaints that accurately indicate prioritisation (O. S. Albahri, Zaidan, et al., 2019).

- **Remote environment:** This point shows whether patient prioritisation is executed in the remote environment. Prioritisation is important to support continuous care of remote patients in a pervasive environment (Sarkar & Sinha, 2014). In remote environments, the overwhelming heterogeneous data from patients cause difficulties in prioritisation.

- **Support vital signs:** This point indicates that the vital signs taken into consideration are used in prioritisation. Vital signs are important in evaluating the patient condition (Sakanushi et al., 2013; O. H. Salman et al., 2014).

- **Support chief complaints:** This point indicates that the chief complaints have been taken into consideration and used in patient prioritisation. In remote healthcare monitoring, non-sensory data are necessary (O. H. Salman et al., 2014).
- **Targeted tier:** Identifying the tier that involves prioritisation. RHM and telemedicine architecture are embodied in three tiers, which are Tier 1 (sensors), Tier 2 (base station) and Tier 3 (remote server) (Chowdhury, Mciver, & Light, 2012; O. H. Salman et al., 2014).

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- **Support Scalability:** This point shows whether scalability has been accommodated and handled. Scalability is the increase in number of patients and is considered a challenge in both RHM and prioritisation (Mciver et al., 2012; O. H. Salman et al., 2014).

- **Prioritisation method Category/Order:** This shows whether the prioritisation supports categories or order methods. Categorisation classifies patients and prioritises them according to levels. The order method provides a rank for patients according their emergency situations. Although most triage systems categorise patients into a priority group, the order of the patients is typically determined using a FCFS principle (David Claudio et al., 2014).

- **Expert opinion:** Selecting the right group of experts is critical for ensuring an accurate outcome.

- **Multi criteria ranking:** This point indicates whether the study addressed the multi criteria in prioritisation (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018). Prioritisation of patients with multiple CHD involves complex multiple DM, which requires a new DM technique to deal with this problem to determine the emergency degree of patients with chronic disease.

- **Handling data variation:** This point involves handling overwhelming data from multiple sources for a large number of patients. Supporting large amount of data is important because overwhelming data could cause difficulty in

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making decisions as to whom the care should be given first and then onwards when numerous patients are involved (Sarkar & Sinha, 2014).

- **Patient Prioritisation Accuracy:** This point indicates the accuracy of the patient prioritisation. It represents the accurate ranking of patients according to their urgent situation, whilst considering their medical condition (Kalid, Zaidan, Zaidan, Salman, Hashim, & Muzammil, 2018). Accuracy is also reflected in the recognition of the slight differences in the urgent situation between patients with MCDs.

- **Important attribute/criteria:** This point shows the weighting process used to determine the importance of attributes in patient prioritisation work. Expert judgements and preferences are useful to extract the weights of attributes used in patient prioritisation (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018).

- **Validation:** This point shows whether a validation has been provided and the methods used for validation.
- **Evaluation:** This point shows whether an evaluation has been provided and the methods used for evaluation.

After recognising and defining the checklist comparison issues, the proposed prioritisation work has been compared with the most relevant remote patient prioritisation study involving these specific issues. Each scenario gains 25% from the

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overall performance (100 divided by 4 scenarios). Four issues have been highlighted for the first scenario; each issue gains 6.25% (25 divided by 4 issues). Six issues have been highlighted for the second scenario; each issue gains 4.16% (25 divided by 6 issues). Four issues have been highlighted for the third scenario, and each issue gains 6.25% (25 divided by 4 issues). Two issues have been highlighted for the last scenario, and each issue gains 12.5% (25 divided by 2 issues).

After the comparison issues of the checklist have been described, the checklist comparison between the proposed and the benchmark studies are presented in Table 5.2 as follows.

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Table 5.2

Checklist Benchmarking

Checklist issues	*Benchmark*	*Proposed*
MCDs	Not supported	Supported.
Remote environment	Supported	Supported.
Support vital signs	Supported	Supported.
Support chief complaints	Supported	Supported.
Support scalability	Supported	Supported.
Multicriteria ranking	Existing multi-criteria DM techniques (integrated AHP-TOPSIS) have been applied in prioritisation to deal with the multiple heterogeneous sources from patients with CHD.	A novel TROOIL technique is proposed to prioritise MCD patients based on the degree of emergency.
Handling data variation	A decision matrix that accommodates a large amount of data is used through listing the alternatives that represent the patients (in column) and the multi criteria that represent the features for evaluating patients.	Decision matrix is created based on the crossover of 'multi-source for each disease' and 'patients list within same rule'. Ten sources related to CHD, one source for systolic and one for diastolic have been utilised.
Important attribute/criteria	MLAHP that extracts the importance of each source and features against the others are used via pairwise comparisons from the judgements of the experts to specify a fixed weight for each feature. The judgements of six experts are used for setting the weights.	In cases where more than one patient applies within the same rule, TROOIL objectively calculates weights to the multi-source criteria; this process contributes to the effective patient prioritisation.
Targeted tier in telemedicine architecture	Tier 3 (server)	Tier 3 (server).
Prioritisation method Category/order	Ranking	Ranking.
Patient prioritisation accuracy	The patients are prioritised through simultaneous consideration of multiple attributes (vital signs and complaints) with respect to the proper weight assigned for each attribute to score the patients on the basis of the most urgent cases. Integrated AHP-TOPSIS provides patient order on the basis of urgency cases for each patient with CHD.	Patients with MCDs are prioritised on the basis of 125 Rules generated and ordered dynamically from the highest to the lowest emergency case by medical committee. As such, the patients are scored based on the most urgent cases for each disease. TROOIL ranks and provides patient order by determining the degree of emergency of each chronic disease for each patient.

(Continue)

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Table 5.2 *(Continued)*

Checklist issues	*Benchmark*	*Proposed*
Expert opinion	Supported	Supported.
Validation	Patient prioritisation has been validated.	Patient prioritisation for each rule has been validated.
Evaluation	The performance has been determined by checklist benchmarking.	The performance of the proposed work has been determined by checklist benchmarking.

As presented in Table 5.2, the checklist benchmarking points have been deliberated between the benchmark and the proposed work. In the first scenario, three issues, including remote environment, vital sign support and support chief complaints are addressed by both works, whilst MCDs as a case study are addressed by the proposed work only. Therefore, in this scenario, the benchmark work gained 18.75% out of 25%, but the proposed work that addressed all the issues in this scenario gained 25%.

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In the second scenario, five issues, including support scalability, handling data variation, important attribute/criteria, remote environment and targeted tier, are addressed by both works, whilst multi-criteria ranking based on a novel technique is addressed only by the proposed work. Therefore, in this scenario, the benchmark work gains 20.8% out of 25%, but the proposed framework that addressed all of the issues in this scenario gains 25%.

The two issues in the third scenario includes prioritisation method, category/order and expert opinion addressed by both work, whereas multi-criteria ranking and patient prioritisation accuracy are only addressed by the proposed work.

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Therefore, in this scenario, the benchmark work gains 12.5% out of 25%, but the proposed work that addressed all the issues in this scenario, gains 25%.

In the fourth scenario, two issues, including validation and evaluation are addressed by both works. Therefore, in this scenario, the benchmark and proposed work gain 25%. The differences in work based on the scenarios and related issues are presented in Table 5.3.

Table 5.3

Comparison Scenarios and their Related Issues in the Benchmark and Proposed Work

Scenarios	*Issues*	*Benchmark*	*Proposed*
First scenario	MCDs	x	√
	Remote environment	√	√
	Support vital signs	√	√
	Support chief complaints	√	√
	Support scalability	√	√
Second scenario	Multi criteria ranking	x	√
	Handling data variation	√	√
	Important attribute/criteria	√	√
	Targeted tier in telemedicine architecture	√	√
	Prioritisation method category/order	√	√
Third scenario	Patient prioritisation accuracy	x	√
	Expert opinion	√	√
Fourth scenario	Validation	√	√
	Evaluation	√	√
Total score		77.05%	100%
Finding difference		22.95%	

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The advantages and strengths of the issues considered in the proposed work and disregarded by the benchmark are as follows:

1- **MCDs:** As the number of chronic conditions of a person increases, his or her risk for premature death, hospitalisation, and even receiving conflicting advice from health care providers increases. People with multiple chronic conditions are at great risk of poor day-to-day functioning. MCDs contribute to frailty and disability. Functional limitations often complicate access to health care, interfere with self-management and necessitate reliance on caregivers (Services, 2010). Thus, improving the healthcare quality for patients with MCDs is important and necessary. To provide suitable healthcare for patients within the telemedicine environment, patients with MCDs must be prioritised and ordered to provide healthcare services as a treatment (Kalid, Zaidan, Zaidan, Salman, Hashim, Albahri, et al., 2018).

2- **Multi criteria ranking :** The purpose of MCDM is to assist decision makers in several fields who are faced with multi-criteria decision problem (Zionts, 1979). MCDM can improve the quality of the decisions through a more rational, explicit and efficient process than that of conventional processes (Oliveira, Fontes, & Pereira, 2013). The existing methods could not deal with the problems on prioritising patients with MCDs within telemedicine environment. This type of prioritisation considers multiple decision making processes that represent the degree of emergency of each chronic disease. Thus, TROOIL has been proposed to deal with such problems.

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3- **Patient Prioritisation Accuracy:** To increase the prioritisation accuracy for patients with MCDs, the emergency degree of each chronic disease must be individually identified from the highest to the lowest emergency case through medical guidelines. Then, emergency levels for all diseases must be grouped under a different rule. All rules should be ordered on the basis of the medical committee from the highest to the lowest emergency cases to increase the accuracy of patient prioritisation. In such case, comparison between several patients can be separated into several clusters, wherein each cluster indicates the different emergency levels to ensure prioritisation accuracy.

In conclusion, considering the issues within all scenarios, the proposed work has an advantage over the benchmark work with a percentage of 22.95%.

5.4 Chapter Summary

The validation and evaluation of the results have been provided in this chapter. Validation has been achieved objectively via the division of the ranking results of the prioritised patients into several groups. Then, mean ± SD have been calculated for each group within each rule to ensure that the prioritised patients undergo a systematic ranking.

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For evaluation, scenarios and checklist benchmarking have been provided to determine the performance of the proposed work compared with that of the benchmark work. Four main scenarios have been described with related issues. These issues are used as comparison points in checklist benchmarking.

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CHAPTER 6

CONCLUSION AND FUTURE WORK

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6.1 Introduction

This chapter highlights the summary of the main findings and contributions, limitations and future work of this research. In Section 6.2, the research goals attained is described, whilst the research contribution is reported in Section 6.3. Section 6.4 presents the research limitations. In Section 6.5, the recommendations for future work are elaborated.

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6.2 Research Goals Attained

The links amongst the research objectives, research methodology and research contributions are framed to demonstrate and explain the attainment of the research goals and to provide research guidance. The research problem statement claims that, in large numbers of critically ill or injured patients, prioritisation of patients with MCDs is an important, difficult and challenging task, which must be measured or evaluated.

To solve the research problems, this study sets four main objectives. For each objective, certain goals must be achieved. Investigating and conducting patient prioritisation problems, environments, methods, gaps, main challenges and specifications for improving the existing applications of patient prioritisation are the goals of the first objective. The analysis after reviewing the existing MCDM techniques suggests that the existing methods cannot be used in prioritising patients with MCDs. Thus, the main goal of the second objective is to propose a new decision technique that deals with multiple decision-making problems. Prioritisation of patients with MCDs based on the proposed decision technique is the goal of the third objective. Finally, the goal of the fourth objective is to validate and evaluate the proposed prioritisation of MCDs..

To achieve the research objectives, the research methodology consists of four phases. Each phase has a corresponding objective, which demonstrates the main conclusion of the research contributions on the basis of the technical analyses of

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research goals in each phase. The links among the Research Objectives, practically, justification and methodology are shown in Table 6.1.

Table 6.1

Connections among Research Objectives, Justification and Methodology

Research Objectives	Practically	Justification	Methodology
1. To investigate the existing technologies of patient prioritisation in telemedicine applications and highlight their weaknesses.	Systematic Review Protocol	Study Selection	Phase: I Preliminary Study
	Taxonomy Design and Description	Gap and Challenge (General Problem)	
	Specify Requirements for prioritize remote patients and case study.	Issues (Specific Problem)	
2. To propose a new decision technique that deals with multiple decision-making for patients with MCDs.	Propose TROOIL technique	To solve the multiple decisions making problem	Phase: 2 Decision Technique
3. To prioritise patients with MCDs on the basis of the proposed decision technique.	Ranking and prioritizing patients' based on TROOIL technique	1.Actual data of patients' needs to be converted into Triage levels of MCDs 2. Rule Generation, Ordering and Validation, which use in the prioritization process need to be provided 3. Triage patients' level and validated rules needs to matched. 4. Mathematical processes need for normalize and aggregate the patients 'triaged data' within each rule	Phase: 3 Prioritization of MCDs Patients'
4. To validate and evaluate the proposed prioritisation of MCDs.	Validation the patients' prioritization Objectively	To ensure that the patients are undergo a systematic ranking	Phase 4: Validation and Evaluation
	Scenarios and checklist benchmarking	Determines the performance of the proposed work comparing with the existing studies.	

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6.3 Research Contributions

This research contributes to patient prioritisation with MCDs over telemedicine. The main contributions of this research are as follows:

1. The proposed TROOIL technique has been presented to deal with the multiple decision-making problems.
2. It has been used to solve multiple decision-making problems of prioritisation of patients with MCDs.

Figure 6.1 shows the main contribution of our study and novelty mapping.

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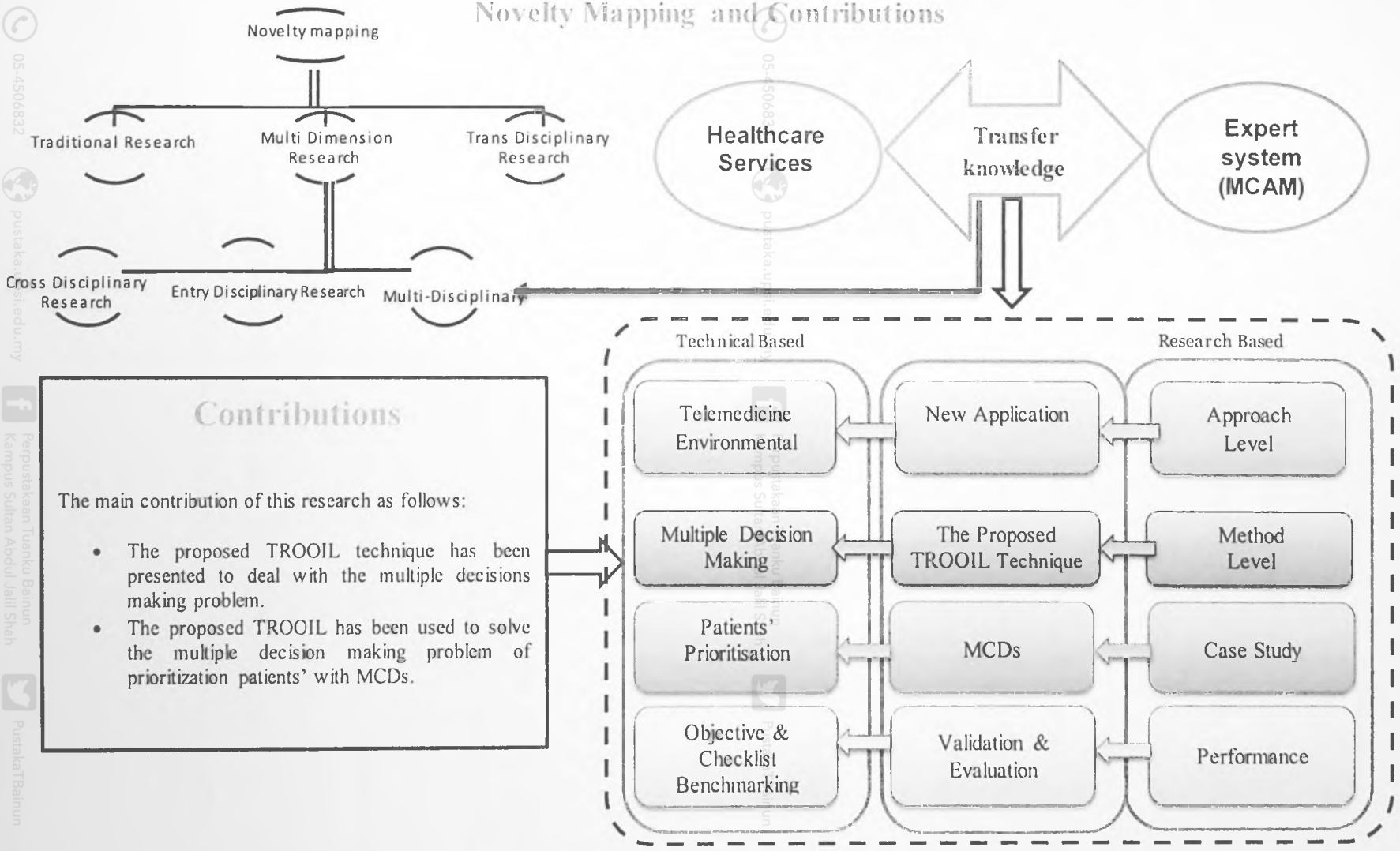


Figure 6.1. Research Contributions and Novelty Mapping

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6.4 Research Limitations

Some limitations can be solved in future research. The present study has several limitations because of the scope of the study. The limitations of this research include data filtering and patient mobility signal processing issues that are assumed to be achieved by other tasks beyond the scope of this research. However, these signal processing issues affect the performance of the evaluation criteria with multiple sources and any failure in these issues can have a negative impact on patient prioritisation in real-time applications. The proposed patient prioritisation with MCDs is not implemented in real-time processing because telemedicine application is not implemented in real situations.

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6.5 Recommendations for Future Work

This study presents several recommendations for future work as follows:

1. MCDs have various complications, such as fall, diabetes, cancer, stroke and arthritis. A future trend of our research is to consider the prioritisation of patients with these types as another case study. Therefore, medical guidelinesmust be improved, and the type and the number of medical features involved should be investigated.
2. Achieving the above point might pave the way for the design of an adaptive decision-making platform for fall detection and different MCDs, such as heart

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diseases, diabetes, BP-related diseases, cancer, stroke and arthritis. The platform can be used to designate priority levels to patients, considering the diversity of diseases and emergency levels of each patient.

3. Extensions of TROOIL technique under fuzzy environment can be implemented to deal with uncertain and imprecise problems.

4. The implementation of the proposed prioritisation work in a real-time application in the whole architecture of wireless healthcare telemonitoring systems is set to be our future work direction.

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APPENDIX (A)

MEDICAL COMMITTEE PERSPECTIVES

Section 1: Questionnaire

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Ranking Questionnaire

Dear Doctors,

The aim behind this questionnaire depends on two purposes; the first purpose of the rules validation is to present the relative importance of all the diseases (CHD, High BP disease, and Low BP disease). Thus, diseases will be prioritized and validated in terms of importance for each one. While the second purpose is to prioritize 125 probabilistic rules that consulted to ensure that the ranking rules valid and accurate. This questionnaire is a part of the research activities towards Ph.D. degree for Khalid Ibrahim Mohammed at Universiti Pendidikan Sultan Idris (UPSI)/Malaysia.

Background:

Name:

Hospital or Agency name:

Years of experience:

E-Mail:

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Table A.1

The rules ranking based on medical committee perspectives

Rules	Diseas 1	Diseas 2	Diseas 3	Ranking by medical committee perspectives	Rules	Diseas 1	Diseas 2	Diseas 3	Ranking by medical committee perspectives
Rule 1	Risk	Risk	Risk		Rule 64	Sick	Sick	Cold State	
Rule 2	Risk	Risk	Urgent		Rule 65	Sick	Sick	Normal	
Rule 3	Risk	Risk	Sick		Rule 66	Sick	Cold State	Risk	
Rule 4	Risk	Risk	Cold State		Rule 67	Sick	Cold State	Urgent	
Rule 5	Risk	Risk	Normal		Rule 68	Sick	Cold State	Sick	
Rule 6	Risk	Urgent	Risk		Rule 69	Sick	Cold State	Cold State	
Rule 7	Risk	Urgent	Urgent		Rule 70	Sick	Cold State	Normal	
Rule 8	Risk	Urgent	Sick		Rule 71	Sick	Normal	Risk	
Rule 9	Risk	Urgent	Cold State		Rule 72	Sick	Normal	Urgent	
Rule 10	Risk	Urgent	Normal		Rule 73	Sick	Normal	Sick	
Rule 11	Risk	Sick	Risk		Rule 74	Sick	Normal	Cold State	
Rule 12	Risk	Sick	Urgent		Rule 75	Sick	Normal	Normal	
Rule 13	Risk	Sick	Sick		Rule 76	Cold State	Risk	Risk	
Rule 14	Risk	Sick	Cold State		Rule 77	Cold State	Risk	Urgent	
Rule 15	Risk	Sick	Normal		Rule 78	Cold State	Risk	Sick	
Rule 16	Risk	Cold State	Risk		Rule 79	Cold State	Risk	Cold State	
Rule 17	Risk	Cold State	Urgent		Rule 80	Cold State	Risk	Normal	
Rule 18	Risk	Cold State	Sick		Rule 81	Cold State	Urgent	Risk	
Rule 19	Risk	Cold State	Cold State		Rule 82	Cold State	Urgent	Urgent	
Rule 20	Risk	Cold State	Normal		Rule 83	Cold State	Urgent	Sick	
Rule 21	Risk	Normal	Risk		Rule 84	Cold State	Urgent	Cold State	
Rule 22	Risk	Normal	Urgent		Rule 85	Cold State	Urgent	Normal	
Rule 23	Risk	Normal	Sick		Rule 86	Cold State	Sick	Risk	
Rule 24	Risk	Normal	Cold State		Rule 87	Cold State	Sick	Urgent	
Rule 25	Risk	Normal	Normal		Rule 88	Cold State	Sick	Sick	
Rule 26	Urgent	Risk	Risk		Rule 89	Cold State	Sick	Cold State	
Rule 27	Urgent	Risk	Urgent		Rule 90	Cold State	Sick	Normal	
Rule 28	Urgent	Risk	Sick		Rule 91	Cold State	Cold State	Risk	
Rule 29	Urgent	Risk	Cold State		Rule 92	Cold State	Cold State	Urgent	
Rule 30	Urgent	Risk	Normal		Rule 93	Cold State	Cold State	Sick	
Rule 31	Urgent	Urgent	Risk		Rule 94	Cold State	Cold State	Cold State	
Rule 32	Urgent	Urgent	Urgent		Rule 95	Cold State	Cold State	Normal	
Rule 33	Urgent	Urgent	Sick		Rule 96	Cold State	Normal	Risk	
Rule 34	Urgent	Urgent	Cold State		Rule 97	Cold State	Normal	Urgent	
Rule 35	Urgent	Urgent	Normal		Rule 98	Cold State	Normal	Sick	
Rule 36	Urgent	Sick	Risk		Rule 99	Cold State	Normal	Cold State	
Rule 37	Urgent	Sick	Urgent		Rule 100	Cold State	Normal	Normal	
Rule 38	Urgent	Sick	Sick		Rule 101	Normal	Risk	Risk	
Rule 39	Urgent	Sick	Cold State		Rule 102	Normal	Risk	Urgent	
Rule 40	Urgent	Sick	Normal		Rule 103	Normal	Risk	Sick	
Rule 41	Urgent	Cold State	Risk		Rule 104	Normal	Risk	Cold State	
Rule 42	Urgent	Cold State	Urgent		Rule 105	Normal	Risk	Normal	
Rule 43	Urgent	Cold State	Sick		Rule 106	Normal	Urgent	Risk	
Rule 44	Urgent	Cold State	Cold State		Rule 107	Normal	Urgent	Urgent	

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Rule 45	Urgent	Cold State	Normal	Rule 108	Normal	Urgent	Sick
Rule 46	Urgent	Normal	Risk	Rule 109	Normal	Urgent	Cold State
Rule 47	Urgent	Normal	Urgent	Rule 110	Normal	Urgent	Normal
Rule 48	Urgent	Normal	Sick	Rule 111	Normal	Sick	Risk
Rule 49	Urgent	Normal	Cold State	Rule 112	Normal	Sick	Urgent
Rule 50	Urgent	Normal	Normal	Rule 113	Normal	Sick	Sick
Rule 51	Sick	Risk	Risk	Rule 114	Normal	Sick	Cold State
Rule 52	Sick	Risk	Urgent	Rule 115	Normal	Sick	Normal
Rule 53	Sick	Risk	Sick	Rule 116	Normal	Cold State	Risk
Rule 54	Sick	Risk	Cold State	Rule 117	Normal	Cold State	Urgent
Rule 55	Sick	Risk	Normal	Rule 118	Normal	Cold State	Sick
Rule 56	Sick	Urgent	Risk	Rule 119	Normal	Cold State	Cold State
Rule 57	Sick	Urgent	Urgent	Rule 120	Normal	Cold State	Normal
Rule 58	Sick	Urgent	Sick	Rule 121	Normal	Normal	Risk
Rule 59	Sick	Urgent	Cold State	Rule 122	Normal	Normal	Urgent
Rule 60	Sick	Urgent	Normal	Rule 123	Normal	Normal	Sick
Rule 61	Sick	Sick	Risk	Rule 124	Normal	Normal	Cold State
Rule 62	Sick	Sick	Urgent	Rule 125	Normal	Normal	Normal
Rule 63	Sick	Sick	Sick				

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Section 2: List of Experts

Table A.2

List of experts of medical committee

Name	*Work place / Country*	*Years of experience*	*Date*
Dr. Abdullah Bahaa Zaidan	Al-Yarmouk Teaching Hospital/ Iraq	More than 10 years	15/10/2018
Dr. Amer Abdullah Mohammed	Al-Yarmouk Teaching Hospital/ Iraq	More than 10 years	15/10/2018
Dr. Ahmed Abd Almanaem	Al-Yarmouk Teaching Hospital/ Iraq	More than 10 years	15/10/2018

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Appendix (B)

Table B.1

Dataset presentation results

P. No.	Spo2	Blood pressure sensor (Systolic/Diastolic)	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	ST El.	HBPD (Systolic)	LBPD (Diastolic)
1	97	230/120	false	false	false	false	67	0.060	0.066	true	230	120
2	97	230/120	false	false	false	true	67	0.060	0.066	true	230	120
3	97	230/120	false	false	true	false	67	0.060	0.066	true	230	120
4	97	230/120	false	false	true	true	67	0.060	0.066	true	230	120
5	97	230/120	false	true	false	false	67	0.060	0.066	true	230	120
6	97	230/120	false	true	false	true	67	0.060	0.066	true	230	120
7	97	230/120	false	true	true	false	67	0.060	0.066	true	230	120
8	97	230/120	false	true	true	true	67	0.060	0.066	true	230	120
9	97	230/120	true	false	false	false	67	0.060	0.066	true	230	120
10	97	230/120	true	false	false	true	67	0.060	0.066	true	230	120
11	97	230/120	true	false	true	false	67	0.060	0.066	true	230	120
12	97	230/120	true	false	true	true	67	0.060	0.066	true	230	120
13	97	230/120	true	true	false	false	67	0.060	0.066	true	230	120
14	97	230/120	true	true	false	true	67	0.060	0.066	true	230	120
15	97	230/120	true	true	true	false	67	0.060	0.066	true	230	120
16	97	230/120	true	true	true	true	67	0.060	0.066	true	230	120
17	92	230/120	false	false	false	false	67	0.060	0.066	true	230	120
18	92	230/120	false	false	false	true	67	0.060	0.066	true	230	120
19	92	230/120	false	false	true	false	67	0.060	0.066	true	230	120
20	92	230/120	false	false	true	true	67	0.060	0.066	true	230	120
21	92	230/120	false	true	false	false	67	0.060	0.066	true	230	120
22	92	230/120	false	true	false	true	67	0.060	0.066	true	230	120
23	92	230/120	false	true	true	false	67	0.060	0.066	true	230	120
24	92	230/120	false	true	true	true	67	0.060	0.066	true	230	120
25	92	230/120	true	false	false	false	67	0.060	0.066	true	230	120
26	92	230/120	true	false	false	true	67	0.060	0.066	true	230	120
27	92	230/120	true	false	true	false	67	0.060	0.066	true	230	120
28	92	230/120	true	false	true	true	67	0.060	0.066	true	230	120
29	92	230/120	true	true	false	false	67	0.060	0.066	true	230	120
30	92	230/120	true	true	false	true	67	0.060	0.066	true	230	120
31	92	230/120	true	true	true	false	67	0.060	0.066	true	230	120
32	92	230/120	true	true	true	true	67	0.060	0.066	true	230	120
33	97	150/100	false	false	false	false	67	0.060	0.066	true	150	100
34	97	150/100	false	false	false	true	67	0.060	0.066	true	150	100
35	97	150/100	false	false	true	false	67	0.060	0.066	true	150	100
36	97	150/100	false	false	true	true	67	0.060	0.066	true	150	100
37	97	150/100	false	true	false	false	67	0.060	0.066	true	150	100
38	97	150/100	false	true	false	true	67	0.060	0.066	true	150	100

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39	97	150/100	false	true	true	false	67	0.060	0.066	true	150	100
40	97	150/100	false	true	true	true	67	0.060	0.066	true	150	100
41	97	150/100	true	false	false	false	67	0.060	0.066	true	150	100
42	97	150/100	true	false	false	true	67	0.060	0.066	true	150	100
43	97	150/100	true	false	true	false	67	0.060	0.066	true	150	100
44	97	150/100	true	false	true	true	67	0.060	0.066	true	150	100
45	97	150/100	true	true	false	false	67	0.060	0.066	true	150	100
46	97	150/100	true	true	false	true	67	0.060	0.066	true	150	100
47	97	150/100	true	true	true	false	67	0.060	0.066	true	150	100
48	97	150/100	true	true	true	true	67	0.060	0.066	true	150	100
49	92	150/100	false	false	false	false	67	0.060	0.066	true	150	100
50	92	150/100	false	false	false	true	67	0.060	0.066	true	150	100
51	92	150/100	false	false	true	false	67	0.060	0.066	true	150	100
52	92	150/100	false	false	true	true	67	0.060	0.066	true	150	100
53	92	150/100	false	true	false	false	67	0.060	0.066	true	150	100
54	92	150/100	false	true	false	true	67	0.060	0.066	true	150	100
55	92	150/100	false	true	true	false	67	0.060	0.066	true	150	100
56	92	150/100	false	true	true	true	67	0.060	0.066	true	150	100
57	92	150/100	true	false	false	false	67	0.060	0.066	true	150	100
58	92	150/100	true	false	false	true	67	0.060	0.066	true	150	100
59	92	150/100	true	false	true	false	67	0.060	0.066	true	150	100
60	92	150/100	true	false	true	true	67	0.060	0.066	true	150	100
61	92	150/100	true	true	false	false	67	0.060	0.066	true	150	100
62	92	150/100	true	true	false	true	67	0.060	0.066	true	150	100
63	92	150/100	true	true	true	false	67	0.060	0.066	true	150	100
64	92	150/100	true	true	true	true	67	0.060	0.066	true	150	100
65	97	120/80	false	false	false	false	67	0.060	0.066	true	120	80
66	97	120/80	false	false	false	true	67	0.060	0.066	true	120	80
67	97	120/80	false	false	true	false	67	0.060	0.066	true	120	80
68	97	120/80	false	false	true	true	67	0.060	0.066	true	120	80
69	97	120/80	false	true	false	false	67	0.060	0.066	true	120	80
70	97	120/80	false	true	false	true	67	0.060	0.066	true	120	80
71	97	120/80	false	true	true	false	67	0.060	0.066	true	120	80
72	97	120/80	false	true	true	true	67	0.060	0.066	true	120	80
73	97	120/80	true	false	false	false	67	0.060	0.066	true	120	80
74	97	120/80	true	false	false	true	67	0.060	0.066	true	120	80
75	97	120/80	true	false	true	false	67	0.060	0.066	true	120	80
76	97	120/80	true	false	true	true	67	0.060	0.066	true	120	80
77	97	120/80	true	true	false	false	67	0.060	0.066	true	120	80
78	97	120/80	true	true	false	true	67	0.060	0.066	true	120	80
79	97	120/80	true	true	true	false	67	0.060	0.066	true	120	80
80	97	120/80	true	true	true	true	67	0.060	0.066	true	120	80
81	92	120/80	false	false	false	false	67	0.060	0.066	true	120	80
82	92	120/80	false	false	false	true	67	0.060	0.066	true	120	80

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83	92	120/80	false	false	true	false	67	0.060	0.066	true	120	80
84	92	120/80	false	false	true	true	67	0.060	0.066	true	120	80
85	92	120/80	false	true	false	false	67	0.060	0.066	true	120	80
86	92	120/80	false	true	false	true	67	0.060	0.066	true	120	80
87	92	120/80	false	true	true	false	67	0.060	0.066	true	120	80
88	92	120/80	false	true	true	true	67	0.060	0.066	true	120	80
89	92	120/80	true	false	false	false	67	0.060	0.066	true	120	80
90	92	120/80	true	false	false	true	67	0.060	0.066	true	120	80
91	92	120/80	true	false	true	false	67	0.060	0.066	true	120	80
92	92	120/80	true	false	true	true	67	0.060	0.066	true	120	80
93	92	120/80	true	true	false	false	67	0.060	0.066	true	120	80
94	92	120/80	true	true	false	true	67	0.060	0.066	true	120	80
95	92	120/80	true	true	true	false	67	0.060	0.066	true	120	80
96	92	120/80	true	true	true	true	67	0.060	0.066	true	120	80
97	80	120/80	false	false	false	false	67	0.060	0.066	true	120	80
98	80	120/80	false	false	false	true	67	0.060	0.066	true	120	80
99	80	120/80	false	false	true	false	67	0.060	0.066	true	120	80
100	80	120/80	false	false	true	true	67	0.060	0.066	true	120	80
101	80	120/80	false	true	false	false	67	0.060	0.066	true	120	80
102	80	120/80	false	true	false	true	67	0.060	0.066	true	120	80
103	80	120/80	false	true	true	false	67	0.060	0.066	true	120	80
104	80	120/80	false	true	true	true	67	0.060	0.066	true	120	80
105	80	120/80	true	false	false	false	67	0.060	0.066	true	120	80
106	80	120/80	true	false	false	true	67	0.060	0.066	true	120	80
107	80	120/80	true	false	true	false	67	0.060	0.066	true	120	80
108	80	120/80	true	false	true	true	67	0.060	0.066	true	120	80
109	80	120/80	true	true	false	false	67	0.060	0.066	true	120	80
110	80	120/80	true	true	false	true	67	0.060	0.066	true	120	80
111	80	120/80	true	true	true	false	67	0.060	0.066	true	120	80
112	80	120/80	true	true	true	true	67	0.060	0.066	true	120	80
113	80	150/100	false	false	false	false	67	0.060	0.066	true	150	100
114	80	150/100	false	false	false	true	67	0.060	0.066	true	150	100
115	80	150/100	false	false	true	false	67	0.060	0.066	true	150	100
116	80	150/100	false	false	true	true	67	0.060	0.066	true	150	100
117	80	150/100	false	true	false	false	67	0.060	0.066	true	150	100
118	80	150/100	false	true	false	true	67	0.060	0.066	true	150	100
119	80	150/100	false	true	true	false	67	0.060	0.066	true	150	100
120	80	150/100	false	true	true	true	67	0.060	0.066	true	150	100
121	80	150/100	true	false	false	false	67	0.060	0.066	true	150	100
122	80	150/100	true	false	false	true	67	0.060	0.066	true	150	100
123	80	150/100	true	false	true	false	67	0.060	0.066	true	150	100
124	80	150/100	true	false	true	true	67	0.060	0.066	true	150	100
125	80	150/100	true	true	false	false	67	0.060	0.066	true	150	100
126	80	150/100	true	true	false	true	67	0.060	0.066	true	150	100

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127	80	150/100	true	true	true	false	67	0.060	0.066	true	150	100
128	80	150/100	true	true	true	true	67	0.060	0.066	true	150	100
129	80	230/120	false	false	false	false	67	0.060	0.066	true	230	120
130	80	230/120	false	false	false	true	67	0.060	0.066	true	230	120
131	80	230/120	false	false	true	false	67	0.060	0.066	true	230	120
132	80	230/120	false	false	true	true	67	0.060	0.066	true	230	120
133	80	230/120	false	true	false	false	67	0.060	0.066	true	230	120
134	80	230/120	false	true	false	true	67	0.060	0.066	true	230	120
135	80	230/120	false	true	true	false	67	0.060	0.066	true	230	120
136	80	230/120	false	true	true	true	67	0.060	0.066	true	230	120
137	80	230/120	true	false	false	false	67	0.060	0.066	true	230	120
138	80	230/120	true	false	false	true	67	0.060	0.066	true	230	120
139	80	230/120	true	false	true	false	67	0.060	0.066	true	230	120
140	80	230/120	true	false	true	true	67	0.060	0.066	true	230	120
141	80	230/120	true	true	false	false	67	0.060	0.066	true	230	120
142	80	230/120	true	true	false	true	67	0.060	0.066	true	230	120
143	80	230/120	true	true	true	false	67	0.060	0.066	true	230	120
144	80	230/120	true	true	true	true	67	0.060	0.066	true	230	120
145	97	230/120	false	false	false	false	54	0.500	0.037	false	230	120
146	97	230/120	false	false	false	true	54	0.500	0.037	false	230	120
147	97	230/120	false	false	true	false	54	0.500	0.037	false	230	120
148	97	230/120	false	false	true	true	54	0.500	0.037	false	230	120
149	97	230/120	false	true	false	false	54	0.500	0.037	false	230	120
150	97	230/120	false	true	false	true	54	0.500	0.037	false	230	120
151	97	230/120	false	true	true	false	54	0.500	0.037	false	230	120
152	97	230/120	false	true	true	true	54	0.500	0.037	false	230	120
153	97	230/120	true	false	false	false	54	0.500	0.037	false	230	120
154	97	230/120	true	false	false	TRUE	54	0.500	0.037	false	230	120
155	97	230/120	true	false	true	false	54	0.500	0.037	false	230	120
156	97	230/120	true	false	true	true	54	0.500	0.037	false	230	120
157	97	230/120	true	true	false	false	54	0.500	0.037	false	230	120
158	97	230/120	true	true	false	true	54	0.500	0.037	false	230	120
159	97	230/120	true	true	true	false	54	0.500	0.037	false	230	120
160	97	230/120	true	true	true	true	54	0.500	0.037	false	230	120
161	92	230/120	false	false	false	false	54	0.500	0.037	false	230	120
162	92	230/120	false	false	false	true	54	0.500	0.037	false	230	120
163	92	230/120	false	false	true	false	54	0.500	0.037	false	230	120
164	92	230/120	false	false	true	true	54	0.500	0.037	false	230	120
165	92	230/120	false	true	false	false	54	0.500	0.037	false	230	120
166	92	230/120	false	true	false	true	54	0.500	0.037	false	230	120
167	92	230/120	false	true	true	false	54	0.500	0.037	false	230	120
168	92	230/120	false	true	true	true	54	0.500	0.037	false	230	120
169	92	230/120	true	false	false	false	54	0.500	0.037	false	230	120
170	92	230/120	true	false	false	true	54	0.500	0.037	false	230	120

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171	92	230/120	true	false	true	false	54	0.500	0.037	false	230	120
172	92	230/120	true	false	true	true	54	0.500	0.037	false	230	120
173	92	230/120	true	true	false	false	54	0.500	0.037	false	230	120
174	92	230/120	true	true	false	true	54	0.500	0.037	false	230	120
175	92	230/120	true	true	true	false	54	0.500	0.037	false	230	120
176	92	230/120	true	true	true	true	54	0.500	0.037	false	230	120
177	97	150/100	false	false	false	false	54	0.500	0.037	false	150	100
178	97	150/100	false	false	false	true	54	0.500	0.037	false	150	100
179	97	150/100	false	false	true	false	54	0.500	0.037	false	150	100
180	97	150/100	false	false	true	true	54	0.500	0.037	false	150	100
181	97	150/100	false	true	false	false	54	0.500	0.037	false	150	100
182	97	150/100	false	true	false	true	54	0.500	0.037	false	150	100
183	97	150/100	false	true	true	false	54	0.500	0.037	false	150	100
184	97	150/100	false	true	true	true	54	0.500	0.037	false	150	100
185	97	150/100	true	false	false	false	54	0.500	0.037	false	150	100
186	97	150/100	true	false	false	true	54	0.500	0.037	false	150	100
187	97	150/100	true	false	true	false	54	0.500	0.037	false	150	100
188	97	150/100	true	false	true	true	54	0.500	0.037	false	150	100
189	97	150/100	true	true	false	false	54	0.500	0.037	false	150	100
190	97	150/100	true	true	false	true	54	0.500	0.037	false	150	100
191	97	150/100	true	true	true	false	54	0.500	0.037	false	150	100
192	97	150/100	true	true	true	true	54	0.500	0.037	false	150	100
193	92	150/100	false	false	false	false	54	0.500	0.037	false	150	100
194	92	150/100	false	false	false	true	54	0.500	0.037	false	150	100
195	92	150/100	false	false	true	false	54	0.500	0.037	false	150	100
196	92	150/100	false	false	true	true	54	0.500	0.037	false	150	100
197	92	150/100	false	true	false	false	54	0.500	0.037	false	150	100
198	92	150/100	false	true	false	true	54	0.500	0.037	false	150	100
199	92	150/100	false	true	true	false	54	0.500	0.037	false	150	100
200	92	150/100	false	true	true	true	54	0.500	0.037	false	150	100
201	92	150/100	true	false	false	false	54	0.500	0.037	false	150	100
202	92	150/100	true	false	false	true	54	0.500	0.037	false	150	100
203	92	150/100	true	false	true	false	54	0.500	0.037	false	150	100
204	92	150/100	true	false	true	true	54	0.500	0.037	false	150	100
205	92	150/100	true	true	false	false	54	0.500	0.037	false	150	100
206	92	150/100	true	true	false	true	54	0.500	0.037	false	150	100
207	92	150/100	true	true	true	false	54	0.500	0.037	false	150	100
208	92	150/100	true	true	true	true	54	0.500	0.037	false	150	100
209	97	120/80	false	false	false	false	54	0.500	0.037	false	120	80
210	97	120/80	false	false	false	true	54	0.500	0.037	false	120	80
211	97	120/80	false	false	true	false	54	0.500	0.037	false	120	80
212	97	120/80	false	false	true	true	54	0.500	0.037	false	120	80
213	97	120/80	false	true	false	false	54	0.500	0.037	false	120	80
214	97	120/80	false	true	false	true	54	0.500	0.037	false	120	80

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215	97	120/80	false	true	true	false	54	0.500	0.037	false	120	80
216	97	120/80	false	true	true	true	54	0.500	0.037	false	120	80
217	97	120/80	true	false	false	false	54	0.500	0.037	false	120	80
218	97	120/80	true	false	false	true	54	0.500	0.037	false	120	80
219	97	120/80	true	false	true	false	54	0.500	0.037	false	120	80
220	97	120/80	true	false	true	true	54	0.500	0.037	false	120	80
221	97	120/80	true	true	false	false	54	0.500	0.037	false	120	80
222	97	120/80	true	true	false	true	54	0.500	0.037	false	120	80
223	97	120/80	true	true	true	false	54	0.500	0.037	false	120	80
224	97	120/80	true	true	true	true	54	0.500	0.037	false	120	80
225	92	120/80	false	false	false	false	54	0.500	0.037	false	120	80
226	92	120/80	false	false	false	true	54	0.500	0.037	false	120	80
227	92	120/80	false	false	true	false	54	0.500	0.037	false	120	80
228	92	120/80	false	false	true	true	54	0.500	0.037	false	120	80
229	92	120/80	false	true	false	false	54	0.500	0.037	false	120	80
230	92	120/80	false	true	false	true	54	0.500	0.037	false	120	80
231	92	120/80	false	true	true	false	54	0.500	0.037	false	120	80
232	92	120/80	false	true	true	true	54	0.500	0.037	false	120	80
233	92	120/80	true	false	false	false	54	0.500	0.037	false	120	80
234	92	120/80	true	false	false	true	54	0.500	0.037	false	120	80
235	92	120/80	true	false	true	false	54	0.500	0.037	false	120	80
236	92	120/80	true	false	true	true	54	0.500	0.037	false	120	80
237	92	120/80	true	true	false	false	54	0.500	0.037	false	120	80
238	92	120/80	true	true	false	true	54	0.500	0.037	false	120	80
239	92	120/80	true	true	true	false	54	0.500	0.037	false	120	80
240	92	120/80	true	true	true	true	54	0.500	0.037	false	120	80
241	80	120/80	false	false	false	false	54	0.500	0.037	false	120	80
242	80	120/80	false	false	false	true	54	0.500	0.037	false	120	80
243	80	120/80	false	false	true	false	54	0.500	0.037	false	120	80
244	80	120/80	false	false	true	true	54	0.500	0.037	false	120	80
245	80	120/80	false	true	false	false	54	0.500	0.037	false	120	80
246	80	120/80	false	true	false	true	54	0.500	0.037	false	120	80
247	80	120/80	false	true	true	false	54	0.500	0.037	false	120	80
248	80	120/80	false	true	true	true	54	0.500	0.037	false	120	80
249	80	120/80	true	false	false	false	54	0.500	0.037	false	120	80
250	80	120/80	true	false	false	true	54	0.500	0.037	false	120	80
251	80	120/80	true	false	true	false	54	0.500	0.037	false	120	80
252	80	120/80	true	false	true	true	54	0.500	0.037	false	120	80
253	80	120/80	true	true	false	false	54	0.500	0.037	false	120	80
254	80	120/80	true	true	false	true	54	0.500	0.037	false	120	80
255	80	120/80	true	true	true	false	54	0.500	0.037	false	120	80
256	80	120/80	true	true	true	true	54	0.500	0.037	false	120	80
257	80	150/100	false	false	false	false	54	0.500	0.037	false	150	100
258	80	150/100	false	false	false	true	54	0.500	0.037	false	150	100

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259	80	150/100	false	false	true	false	54	0.500	0.037	false	150	100
260	80	150/100	false	false	true	true	54	0.500	0.037	false	150	100
261	80	150/100	false	true	false	false	54	0.500	0.037	false	150	100
262	80	150/100	false	true	false	true	54	0.500	0.037	false	150	100
263	80	150/100	false	true	true	false	54	0.500	0.037	false	150	100
264	80	150/100	false	true	true	true	54	0.500	0.037	false	150	100
265	80	150/100	true	false	false	false	54	0.500	0.037	false	150	100
266	80	150/100	true	false	false	true	54	0.500	0.037	false	150	100
267	80	150/100	true	false	true	false	54	0.500	0.037	false	150	100
268	80	150/100	true	false	true	true	54	0.500	0.037	false	150	100
269	80	150/100	true	true	false	false	54	0.500	0.037	false	150	100
270	80	150/100	true	true	false	true	54	0.500	0.037	false	150	100
271	80	150/100	true	true	true	false	54	0.500	0.037	false	150	100
272	80	150/100	true	true	true	true	54	0.500	0.037	false	150	100
273	80	230/120	false	false	false	false	54	0.500	0.037	false	230	120
274	80	230/120	false	false	false	true	54	0.500	0.037	false	230	120
275	80	230/120	false	false	true	false	54	0.500	0.037	false	230	120
276	80	230/120	false	false	true	true	54	0.500	0.037	false	230	120
277	80	230/120	false	true	false	false	54	0.500	0.037	false	230	120
278	80	230/120	false	true	false	true	54	0.500	0.037	false	230	120
279	80	230/120	false	true	true	false	54	0.500	0.037	false	230	120
280	80	230/120	false	true	true	true	54	0.500	0.037	false	230	120
281	80	230/120	true	false	false	false	54	0.500	0.037	false	230	120
282	80	230/120	true	false	false	true	54	0.500	0.037	false	230	120
283	80	230/120	true	false	true	false	54	0.500	0.037	false	230	120
284	80	230/120	true	false	true	true	54	0.500	0.037	false	230	120
285	80	230/120	true	true	false	false	54	0.500	0.037	false	230	120
286	80	230/120	true	true	false	true	54	0.500	0.037	false	230	120
287	80	230/120	true	true	true	false	54	0.500	0.037	false	230	120
288	80	230/120	true	true	true	true	54	0.500	0.037	false	230	120
289	97	230/120	false	false	false	false	77	0.047	0.267	true	230	120
290	97	230/120	false	false	false	true	77	0.047	0.267	true	230	120
291	97	230/120	false	false	true	false	77	0.047	0.267	true	230	120
292	97	230/120	false	false	true	true	77	0.047	0.267	true	230	120
293	97	230/120	false	true	false	false	77	0.047	0.267	true	230	120
294	97	230/120	false	true	false	true	77	0.047	0.267	true	230	120
295	97	230/120	false	true	true	false	77	0.047	0.267	true	230	120
296	97	230/120	false	true	true	true	77	0.047	0.267	true	230	120
297	97	230/120	true	false	false	false	77	0.047	0.267	true	230	120
298	97	230/120	true	false	false	true	77	0.047	0.267	true	230	120
299	97	230/120	true	false	true	false	77	0.047	0.267	true	230	120
300	97	230/120	true	false	true	true	77	0.047	0.267	true	230	120
301	97	230/120	true	true	false	false	77	0.047	0.267	true	230	120
302	97	230/120	true	true	false	true	77	0.047	0.267	true	230	120

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303	97	230/120	true	true	true	false	77	0.047	0.267	true	230	120
304	97	230/120	true	true	true	true	77	0.047	0.267	true	230	120
305	92	230/120	false	false	false	false	77	0.047	0.267	true	230	120
306	92	230/120	false	false	false	true	77	0.047	0.267	true	230	120
307	92	230/120	false	false	true	false	77	0.047	0.267	true	230	120
308	92	230/120	false	false	true	true	77	0.047	0.267	true	230	120
309	92	230/120	false	true	false	false	77	0.047	0.267	true	230	120
310	92	230/120	false	true	false	true	77	0.047	0.267	true	230	120
311	92	230/120	false	true	true	false	77	0.047	0.267	true	230	120
312	92	230/120	false	true	true	true	77	0.047	0.267	true	230	120
313	92	230/120	true	false	false	false	77	0.047	0.267	true	230	120
314	92	230/120	true	false	false	true	77	0.047	0.267	true	230	120
315	92	230/120	true	false	true	false	77	0.047	0.267	true	230	120
316	92	230/120	true	false	true	true	77	0.047	0.267	true	230	120
317	92	230/120	true	true	false	false	77	0.047	0.267	true	230	120
318	92	230/120	true	true	false	true	77	0.047	0.267	true	230	120
319	92	230/120	true	true	true	false	77	0.047	0.267	true	230	120
320	92	230/120	true	true	true	true	77	0.047	0.267	true	230	120
321	97	150/100	false	false	false	false	77	0.047	0.267	true	150	100
322	97	150/100	false	false	false	true	77	0.047	0.267	true	150	100
323	97	150/100	false	false	true	false	77	0.047	0.267	true	150	100
324	97	150/100	false	false	true	true	77	0.047	0.267	true	150	100
325	97	150/100	false	true	false	false	77	0.047	0.267	true	150	100
326	97	150/100	false	true	false	true	77	0.047	0.267	true	150	100
327	97	150/100	false	true	true	false	77	0.047	0.267	true	150	100
328	97	150/100	false	true	true	true	77	0.047	0.267	true	150	100
329	97	150/100	true	false	false	false	77	0.047	0.267	true	150	100
330	97	150/100	true	false	false	true	77	0.047	0.267	true	150	100
331	97	150/100	true	false	true	false	77	0.047	0.267	true	150	100
332	97	150/100	true	false	true	true	77	0.047	0.267	true	150	100
333	97	150/100	true	true	false	false	77	0.047	0.267	true	150	100
334	97	150/100	true	true	false	true	77	0.047	0.267	true	150	100
335	97	150/100	true	true	true	false	77	0.047	0.267	true	150	100
336	97	150/100	true	true	true	true	77	0.047	0.267	true	150	100
337	92	150/100	false	false	false	false	77	0.047	0.267	true	150	100
338	92	150/100	false	false	false	true	77	0.047	0.267	true	150	100
339	92	150/100	false	false	true	false	77	0.047	0.267	true	150	100
340	92	150/100	false	false	true	true	77	0.047	0.267	true	150	100
341	92	150/100	false	true	false	false	77	0.047	0.267	true	150	100
342	92	150/100	false	true	false	true	77	0.047	0.267	true	150	100
343	92	150/100	false	true	true	false	77	0.047	0.267	true	150	100
344	92	150/100	false	true	true	true	77	0.047	0.267	true	150	100
345	92	150/100	true	false	false	false	77	0.047	0.267	true	150	100
346	92	150/100	true	false	false	true	77	0.047	0.267	true	150	100

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347	92	150/100	true	false	true	false	77	0.047	0.267	true	150	100
348	92	150/100	true	false	true	true	77	0.047	0.267	true	150	100
349	92	150/100	true	true	false	false	77	0.047	0.267	true	150	100
350	92	150/100	true	true	false	true	77	0.047	0.267	true	150	100
351	92	150/100	true	true	true	false	77	0.047	0.267	true	150	100
352	92	150/100	true	true	true	true	77	0.047	0.267	true	150	100
353	97	120/80	false	false	false	false	77	0.047	0.267	true	120	80
354	97	120/80	false	false	false	true	77	0.047	0.267	true	120	80
355	97	120/80	false	false	true	false	77	0.047	0.267	true	120	80
356	97	120/80	false	false	true	true	77	0.047	0.267	true	120	80
357	97	120/80	false	true	false	false	77	0.047	0.267	true	120	80
358	97	120/80	false	true	false	true	77	0.047	0.267	true	120	80
359	97	120/80	false	true	true	false	77	0.047	0.267	true	120	80
360	97	120/80	false	true	true	true	77	0.047	0.267	true	120	80
361	97	120/80	true	false	false	false	77	0.047	0.267	true	120	80
362	97	120/80	true	false	false	true	77	0.047	0.267	true	120	80
363	97	120/80	true	false	true	false	77	0.047	0.267	true	120	80
364	97	120/80	true	false	true	true	77	0.047	0.267	true	120	80
365	97	120/80	true	true	false	false	77	0.047	0.267	true	120	80
366	97	120/80	true	true	false	true	77	0.047	0.267	true	120	80
367	97	120/80	true	true	true	false	77	0.047	0.267	true	120	80
368	97	120/80	true	true	true	true	77	0.047	0.267	true	120	80
369	92	120/80	false	false	false	false	77	0.047	0.267	true	120	80
370	92	120/80	false	false	false	true	77	0.047	0.267	true	120	80
371	92	120/80	false	false	true	false	77	0.047	0.267	true	120	80
372	92	120/80	false	false	true	true	77	0.047	0.267	true	120	80
373	92	120/80	false	true	false	false	77	0.047	0.267	true	120	80
374	92	120/80	false	true	false	true	77	0.047	0.267	true	120	80
375	92	120/80	false	true	true	false	77	0.047	0.267	true	120	80
376	92	120/80	false	true	true	true	77	0.047	0.267	true	120	80
377	92	120/80	true	false	false	false	77	0.047	0.267	true	120	80
378	92	120/80	true	false	false	true	77	0.047	0.267	true	120	80
379	92	120/80	true	false	true	false	77	0.047	0.267	true	120	80
380	92	120/80	true	false	true	true	77	0.047	0.267	true	120	80
381	92	120/80	true	true	false	false	77	0.047	0.267	true	120	80
382	92	120/80	true	true	false	true	77	0.047	0.267	true	120	80
383	92	120/80	true	true	true	false	77	0.047	0.267	true	120	80
384	92	120/80	true	true	true	true	77	0.047	0.267	true	120	80
385	80	120/80	false	false	false	false	77	0.047	0.267	true	120	80
386	80	120/80	false	false	false	true	77	0.047	0.267	true	120	80
387	80	120/80	false	false	true	false	77	0.047	0.267	true	120	80
388	80	120/80	false	false	true	true	77	0.047	0.267	true	120	80
389	80	120/80	false	true	false	false	77	0.047	0.267	true	120	80
390	80	120/80	false	true	false	true	77	0.047	0.267	true	120	80

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391	80	120/80	false	true	true	false	77	0.047	0.267	true	120	80
392	80	120/80	false	true	true	true	77	0.047	0.267	true	120	80
393	80	120/80	true	false	false	false	77	0.047	0.267	true	120	80
394	80	120/80	true	false	false	true	77	0.047	0.267	true	120	80
395	80	120/80	true	false	true	false	77	0.047	0.267	true	120	80
396	80	120/80	true	false	true	true	77	0.047	0.267	true	120	80
397	80	120/80	true	true	false	false	77	0.047	0.267	true	120	80
398	80	120/80	true	true	false	true	77	0.047	0.267	true	120	80
399	80	120/80	true	true	true	false	77	0.047	0.267	true	120	80
400	80	120/80	true	true	true	true	77	0.047	0.267	true	120	80
401	80	150/100	false	false	false	false	77	0.047	0.267	true	150	100
402	80	150/100	false	false	false	true	77	0.047	0.267	true	150	100
403	80	150/100	false	false	true	false	77	0.047	0.267	true	150	100
404	80	150/100	false	false	true	true	77	0.047	0.267	true	150	100
405	80	150/100	false	true	false	false	77	0.047	0.267	true	150	100
406	80	150/100	false	true	false	true	77	0.047	0.267	true	150	100
407	80	150/100	false	true	true	false	77	0.047	0.267	true	150	100
408	80	150/100	false	true	true	true	77	0.047	0.267	true	150	100
409	80	150/100	true	false	false	false	77	0.047	0.267	true	150	100
410	80	150/100	true	false	false	true	77	0.047	0.267	true	150	100
411	80	150/100	true	false	true	false	77	0.047	0.267	true	150	100
412	80	150/100	true	false	true	true	77	0.047	0.267	true	150	100
413	80	150/100	true	true	false	false	77	0.047	0.267	true	150	100
414	80	150/100	true	true	false	true	77	0.047	0.267	true	150	100
415	80	150/100	true	true	true	false	77	0.047	0.267	true	150	100
416	80	150/100	true	true	true	true	77	0.047	0.267	true	150	100
417	80	230/120	false	false	false	false	77	0.047	0.267	true	230	120
418	80	230/120	false	false	false	true	77	0.047	0.267	true	230	120
419	80	230/120	false	false	true	false	77	0.047	0.267	true	230	120
420	80	230/120	false	false	true	true	77	0.047	0.267	true	230	120
421	80	230/120	false	true	false	false	77	0.047	0.267	true	230	120
422	80	230/120	false	true	false	true	77	0.047	0.267	true	230	120
423	80	230/120	false	true	true	false	77	0.047	0.267	true	230	120
424	80	230/120	false	true	true	true	77	0.047	0.267	true	230	120
425	80	230/120	true	false	false	false	77	0.047	0.267	true	230	120
426	80	230/120	true	false	false	true	77	0.047	0.267	true	230	120
427	80	230/120	true	false	true	false	77	0.047	0.267	true	230	120
428	80	230/120	true	false	true	true	77	0.047	0.267	true	230	120
429	80	230/120	true	true	false	false	77	0.047	0.267	true	230	120
430	80	230/120	true	true	false	true	77	0.047	0.267	true	230	120
431	80	230/120	true	true	true	false	77	0.047	0.267	true	230	120
432	80	230/120	true	true	true	true	77	0.047	0.267	true	230	120
433	97	230/120	false	false	false	false	64	0.169	0.336	false	230	120
434	97	230/120	false	false	false	true	64	0.169	0.336	false	230	120

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435	97	230/120	false	false	true	false	64	0.169	0.336	false	230	120
436	97	230/120	false	false	true	true	64	0.169	0.336	false	230	120
437	97	230/120	false	true	false	false	64	0.169	0.336	false	230	120
438	97	230/120	false	true	false	true	64	0.169	0.336	false	230	120
439	97	230/120	false	true	true	false	64	0.169	0.336	false	230	120
440	97	230/120	false	true	true	true	64	0.169	0.336	false	230	120
441	97	230/120	true	false	false	false	64	0.169	0.336	false	230	120
442	97	230/120	true	false	false	true	64	0.169	0.336	false	230	120
443	97	230/120	true	false	true	false	64	0.169	0.336	false	230	120
444	97	230/120	true	false	true	true	64	0.169	0.336	false	230	120
445	97	230/120	true	true	false	false	64	0.169	0.336	false	230	120
446	97	230/120	true	true	false	true	64	0.169	0.336	false	230	120
447	97	230/120	true	true	true	false	64	0.169	0.336	false	230	120
448	97	230/120	true	true	true	true	64	0.169	0.336	false	230	120
449	92	230/120	false	false	false	false	64	0.169	0.336	false	230	120
450	92	230/120	false	false	false	true	64	0.169	0.336	false	230	120
451	92	230/120	false	false	true	false	64	0.169	0.336	false	230	120
452	92	230/120	false	false	true	true	64	0.169	0.336	false	230	120
453	92	230/120	false	true	false	false	64	0.169	0.336	false	230	120
454	92	230/120	false	true	false	true	64	0.169	0.336	false	230	120
455	92	230/120	false	true	true	false	64	0.169	0.336	false	230	120
456	92	230/120	false	true	true	true	64	0.169	0.336	false	230	120
457	92	230/120	true	false	false	false	64	0.169	0.336	false	230	120
458	92	230/120	true	false	false	true	64	0.169	0.336	false	230	120
459	92	230/120	true	false	true	false	64	0.169	0.336	false	230	120
460	92	230/120	true	false	true	true	64	0.169	0.336	false	230	120
461	92	230/120	true	true	false	false	64	0.169	0.336	false	230	120
462	92	230/120	true	true	false	true	64	0.169	0.336	false	230	120
463	92	230/120	true	true	true	false	64	0.169	0.336	false	230	120
464	92	230/120	true	true	true	true	64	0.169	0.336	false	230	120
465	97	150/100	false	false	false	false	64	0.169	0.336	false	150	100
466	97	150/100	false	false	false	true	64	0.169	0.336	false	150	100
467	97	150/100	false	false	true	false	64	0.169	0.336	false	150	100
468	97	150/100	false	false	true	true	64	0.169	0.336	false	150	100
469	97	150/100	false	true	false	false	64	0.169	0.336	false	150	100
470	97	150/100	false	true	false	true	64	0.169	0.336	false	150	100
471	97	150/100	false	true	true	false	64	0.169	0.336	false	150	100
472	97	150/100	false	true	true	true	64	0.169	0.336	false	150	100
473	97	150/100	true	false	false	false	64	0.169	0.336	false	150	100
474	97	150/100	true	false	false	true	64	0.169	0.336	false	150	100
475	97	150/100	true	false	true	false	64	0.169	0.336	false	150	100
476	97	150/100	true	false	true	true	64	0.169	0.336	false	150	100
477	97	150/100	true	true	false	false	64	0.169	0.336	false	150	100
478	97	150/100	true	true	false	true	64	0.169	0.336	false	150	100

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479	97	150/100	true	true	true	false	64	0.169	0.336	false	150	100
480	97	150/100	true	true	true	true	64	0.169	0.336	false	150	100
481	92	150/100	false	false	false	false	64	0.169	0.336	false	150	100
482	92	150/100	false	false	false	true	64	0.169	0.336	false	150	100
483	92	150/100	false	false	true	false	64	0.169	0.336	false	150	100
484	92	150/100	false	false	true	true	64	0.169	0.336	false	150	100
485	92	150/100	false	true	false	false	64	0.169	0.336	false	150	100
486	92	150/100	false	true	false	true	64	0.169	0.336	false	150	100
487	92	150/100	false	true	true	false	64	0.169	0.336	false	150	100
488	92	150/100	false	true	true	true	64	0.169	0.336	false	150	100
489	92	150/100	true	false	false	false	64	0.169	0.336	false	150	100
490	92	150/100	true	false	false	true	64	0.169	0.336	false	150	100
491	92	150/100	true	false	true	false	64	0.169	0.336	false	150	100
492	92	150/100	true	false	true	true	64	0.169	0.336	false	150	100
493	92	150/100	true	true	false	false	64	0.169	0.336	false	150	100
494	92	150/100	true	true	false	true	64	0.169	0.336	false	150	100
495	92	150/100	true	true	true	false	64	0.169	0.336	false	150	100
496	92	150/100	true	true	true	true	64	0.169	0.336	false	150	100
497	97	120/80	false	false	false	false	64	0.169	0.336	false	120	80
498	97	120/80	false	false	false	true	64	0.169	0.336	false	120	80
499	97	120/80	false	false	true	false	64	0.169	0.336	false	120	80
500	97	120/80	false	false	true	true	64	0.169	0.336	false	120	80

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Appendix (C)

Table C.1
The overall triage level results

P. No	TCHD	THBPD	TLBPD	p.no	TCHD	THBPD	TLBPD
1	Sick	Risk	Risk	251	Urgent	Normal	Normal
2	Sick	Risk	Risk	252	Urgent	Normal	Normal
3	Sick	Risk	Risk	253	Sick	Normal	Normal
4	Sick	Risk	Risk	254	Urgent	Normal	Normal
5	Sick	Risk	Risk	255	Urgent	Normal	Normal
6	Sick	Risk	Risk	256	Urgent	Normal	Normal
7	Sick	Risk	Risk	257	Sick	Sick	Urgent
8	Urgent	Risk	Risk	258	Sick	Sick	Urgent
9	Sick	Risk	Risk	259	Sick	Sick	Urgent
10	Urgent	Risk	Risk	260	Sick	Sick	Urgent
11	Urgent	Risk	Risk	261	Sick	Sick	Urgent
12	Urgent	Risk	Risk	262	Sick	Sick	Urgent
13	Urgent	Risk	Risk	263	Sick	Sick	Urgent
14	Urgent	Risk	Risk	264	Urgent	Sick	Urgent
15	Risk	Risk	Risk	265	Sick	Sick	Urgent
16	Risk	Risk	Risk	266	Urgent	Sick	Urgent
17	Sick	Risk	Risk	267	Urgent	Sick	Urgent
18	Sick	Risk	Risk	268	Urgent	Sick	Urgent
19	Sick	Risk	Risk	269	Urgent	Sick	Urgent
20	Urgent	Risk	Risk	270	Urgent	Sick	Urgent
21	Sick	Risk	Risk	271	Risk	Sick	Urgent
22	Sick	Risk	Risk	272	Risk	Sick	Urgent
23	Urgent	Risk	Risk	273	Sick	Risk	Risk
24	Urgent	Risk	Risk	274	Sick	Risk	Risk
25	Urgent	Risk	Risk	275	Sick	Risk	Risk
26	Urgent	Risk	Risk	276	Urgent	Risk	Risk
27	Risk	Risk	Risk	277	Sick	Risk	Risk
28	Risk	Risk	Risk	278	Sick	Risk	Risk
29	Urgent	Risk	Risk	279	Urgent	Risk	Risk
30	Urgent	Risk	Risk	280	Urgent	Risk	Risk
31	Risk	Risk	Risk	281	Urgent	Risk	Risk
32	Risk	Risk	Risk	282	Urgent	Risk	Risk
33	Sick	Sick	Urgent	283	risk	Risk	Risk
34	Sick	Sick	Urgent	284	risk	Risk	Risk
35	Sick	Sick	Urgent	285	Urgent	Risk	Risk
36	Sick	Sick	Urgent	286	Urgent	Risk	Risk
37	Sick	Sick	Urgent	287	Risk	Risk	Risk
38	Sick	Sick	Urgent	288	Risk	Risk	Risk
39	Sick	Sick	Urgent	289	Sick	Risk	Risk

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40	Sick	Sick	Urgent	290	Sick	Risk	Risk
41	Sick	Sick	Urgent	291	Sick	Risk	Risk
42	Sick	Sick	Urgent	292	Sick	Risk	Risk
43	Urgent	Sick	Urgent	293	Sick	Risk	Risk
44	Urgent	Sick	Urgent	294	Sick	Risk	Risk
45	Sick	Sick	Urgent	295	Urgent	Risk	Risk
46	Urgent	Sick	Urgent	296	Urgent	Risk	Risk
47	Urgent	Sick	Urgent	297	Urgent	Risk	Risk
48	Urgent	Sick	Urgent	298	Urgent	Risk	Risk
49	Sick	Sick	Urgent	299	risk	Risk	Risk
50	Sick	Sick	Urgent	300	risk	Risk	Risk
51	Sick	Sick	Urgent	301	Urgent	Risk	Risk
52	Sick	Sick	Urgent	302	Urgent	Risk	Risk
53	Sick	Sick	Urgent	303	risk	Risk	Risk
54	Sick	Sick	Urgent	304	risk	Risk	Risk
55	Sick	Sick	Urgent	305	Sick	Risk	Risk
56	Urgent	Sick	Urgent	306	Sick	Risk	Risk
57	Sick	Sick	Urgent	307	Urgent	Risk	Risk
58	Urgent	Sick	Urgent	308	Urgent	Risk	Risk
59	Urgent	Sick	Urgent	309	Sick	Risk	Risk
60	Urgent	Sick	Urgent	310	Sick	Risk	Risk
61	Urgent	Sick	Urgent	311	Urgent	Risk	Risk
62	Urgent	Sick	Urgent	312	Urgent	Risk	Risk
63	Risk	Sick	Urgent	313	Urgent	Risk	Risk
64	Risk	Sick	Urgent	314	Urgent	Risk	Risk
65	Cold State	Normal	Normal	315	risk	Risk	Risk
66	Cold State	Normal	Normal	316	risk	Risk	Risk
67	Sick	Normal	Normal	317	risk	Risk	Risk
68	Sick	Normal	Normal	318	risk	Risk	Risk
69	Sick	Normal	Normal	319	risk	Risk	Risk
70	Sick	Normal	Normal	320	risk	Risk	Risk
71	Sick	Normal	Normal	321	Sick	Sick	Urgent
72	Sick	Normal	Normal	322	Sick	Sick	Urgent
73	Sick	Normal	Normal	323	Sick	Sick	Urgent
74	Sick	Normal	Normal	324	Sick	Sick	Urgent
75	Sick	Normal	Normal	325	Sick	Sick	Urgent
76	Urgent	Normal	Normal	326	Sick	Sick	Urgent
77	Sick	Normal	Normal	327	Sick	Sick	Urgent
78	Sick	Normal	Normal	328	Sick	Sick	Urgent
79	Urgent	Normal	Normal	329	Sick	Sick	Urgent
80	Urgent	Normal	Normal	330	Sick	Sick	Urgent
81	Sick	Normal	Normal	331	Urgent	Sick	Urgent
82	Sick	Normal	Normal	332	Urgent	Sick	Urgent
83	Sick	Normal	Normal	333	Urgent	Sick	Urgent
84	Sick	Normal	Normal	334	Urgent	Sick	Urgent
85	Sick	Normal	Normal	335	Risk	Sick	Urgent

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86	Sick	Normal	Normal	336	Risk	Sick	Urgent
87	Sick	Normal	Normal	337	Sick	Sick	Urgent
88	Sick	Normal	Normal	338	Sick	Sick	Urgent
89	Sick	Normal	Normal	339	Sick	Sick	Urgent
90	Sick	Normal	Normal	340	Sick	Sick	Urgent
91	Urgent	Normal	Normal	341	Sick	Sick	Urgent
92	Urgent	Normal	Normal	342	Sick	Sick	Urgent
93	Sick	Normal	Normal	343	Urgent	Sick	Urgent
94	Urgent	Normal	Normal	344	Urgent	Sick	Urgent
95	Urgent	Normal	Normal	345	Urgent	Sick	Urgent
96	Urgent	Normal	Normal	346	Urgent	Sick	Urgent
97	Sick	Normal	Normal	347	Risk	Sick	Urgent
98	Sick	Normal	Normal	348	Risk	Sick	Urgent
99	Sick	Normal	Normal	349	Urgent	Sick	Urgent
100	Sick	Normal	Normal	350	Urgent	Sick	Urgent
101	Sick	Normal	Normal	351	Risk	Sick	Urgent
102	Sick	Normal	Normal	352	Risk	Sick	Urgent
103	Sick	Normal	Normal	353	Cold State	Normal	Normal
104	Urgent	Normal	Normal	354	Sick	Normal	Normal
105	Sick	Normal	Normal	355	Sick	Normal	Normal
106	Urgent	Normal	Normal	356	Sick	Normal	Normal
107	Urgent	Normal	Normal	357	Sick	Normal	Normal
108	Urgent	Normal	Normal	358	Sick	Normal	Normal
109	Urgent	Normal	Normal	359	Sick	Normal	Normal
110	Urgent	Normal	Normal	360	Sick	Normal	Normal
111	Risk	Normal	Normal	361	Sick	Normal	Normal
112	Risk	Normal	Normal	362	Sick	Normal	Normal
113	Sick	Sick	Urgent	363	Urgent	Normal	Normal
114	Sick	Sick	Urgent	364	Urgent	Normal	Normal
115	Sick	Sick	Urgent	365	Sick	Normal	Normal
116	Urgent	Sick	Urgent	366	Sick	Normal	Normal
117	Sick	Sick	Urgent	367	Urgent	Normal	Normal
118	Sick	Sick	Urgent	368	Urgent	Normal	Normal
119	Urgent	Sick	Urgent	369	Sick	Normal	Normal
120	Urgent	Sick	Urgent	370	Sick	Normal	Normal
121	Urgent	Sick	Urgent	371	Sick	Normal	Normal
122	Urgent	Sick	Urgent	372	Sick	Normal	Normal
123	Risk	Sick	Urgent	373	Sick	Normal	Normal
124	Risk	Sick	Urgent	374	Sick	Normal	Normal
125	Urgent	Sick	Urgent	375	Sick	Normal	Normal
126	Urgent	Sick	Urgent	376	Sick	Normal	Normal
127	Risk	Sick	Urgent	377	Sick	Normal	Normal
128	Risk	Sick	Urgent	378	Sick	Normal	Normal
129	Sick	Risk	Risk	379	Urgent	Normal	Normal
130	Sick	Risk	Risk	380	Urgent	Normal	Normal
131	Urgent	Risk	Risk	381	Urgent	Normal	Normal

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132	Urgent	Risk	Risk	382	Urgent	Normal	Normal
133	Sick	Risk	Risk	383	Risk	Normal	Normal
134	Urgent	Risk	Risk	384	Risk	Normal	Normal
135	Urgent	Risk	Risk	385	Sick	Normal	Normal
136	Urgent	Risk	Risk	386	Sick	Normal	Normal
137	Urgent	Risk	Risk	387	Sick	Normal	Normal
138	Urgent	Risk	Risk	388	Sick	Normal	Normal
139	Risk	Risk	Risk	389	Sick	Normal	Normal
140	Risk	Risk	Risk	390	Sick	Normal	Normal
141	Risk	Risk	Risk	391	Urgent	Normal	Normal
142	Risk	Risk	Risk	392	Urgent	Normal	Normal
143	Risk	Risk	Risk	393	Urgent	Normal	Normal
144	Risk	Risk	Risk	394	Urgent	Normal	Normal
145	Sick	Risk	Risk	395	Risk	Normal	Normal
146	Sick	Risk	Risk	396	Risk	Normal	Normal
147	Sick	Risk	Risk	397	Urgent	Normal	Normal
148	Sick	Risk	Risk	398	Urgent	Normal	Normal
149	Sick	Risk	Risk	399	Risk	Normal	Normal
150	Sick	Risk	Risk	400	Risk	Normal	Normal
151	Sick	Risk	Risk	401	Sick	Sick	Urgent
152	Sick	Risk	Risk	402	Sick	Sick	Urgent
153	Sick	Risk	Risk	403	Urgent	Sick	Urgent
154	Sick	Risk	Risk	404	Urgent	Sick	Urgent
155	Urgent	Risk	Risk	405	Sick	Sick	Urgent
156	Urgent	Risk	Risk	406	Sick	Sick	Urgent
157	Sick	Risk	Risk	407	Urgent	Sick	Urgent
158	Urgent	Risk	Risk	408	Urgent	Sick	Urgent
159	Urgent	Risk	Risk	409	Urgent	Sick	Urgent
160	Urgent	Risk	Risk	410	Urgent	Sick	Urgent
161	Sick	Risk	Risk	411	Risk	Sick	Urgent
162	Sick	Risk	Risk	412	Risk	Sick	Urgent
163	Sick	Risk	Risk	413	Risk	Sick	Urgent
164	Sick	Risk	Risk	414	Risk	Sick	Urgent
165	Sick	Risk	Risk	415	Risk	Sick	Urgent
166	Sick	Risk	Risk	416	Risk	Sick	Urgent
167	Sick	Risk	Risk	417	Sick	Risk	Risk
168	Urgent	Risk	Risk	418	Sick	Risk	Risk
169	Sick	Risk	Risk	419	Urgent	Risk	Risk
170	Urgent	Risk	Risk	420	Urgent	Risk	Risk
171	Urgent	Risk	Risk	421	Urgent	Risk	Risk
172	Urgent	Risk	Risk	422	Urgent	Risk	Risk
173	Urgent	Risk	Risk	423	Risk	Risk	Risk
174	Urgent	Risk	Risk	424	Risk	Risk	Risk
175	Risk	Risk	Risk	425	Risk	Risk	Risk
176	Risk	Risk	Risk	426	Risk	Risk	Risk
177	Cold State	Sick	Urgent	427	Risk	Risk	Risk

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178	Cold State	Sick	Urgent	428	Risk	Risk	Risk
179	Sick	Sick	Urgent	429	Risk	Risk	Risk
180	Sick	Sick	Urgent	430	Risk	Risk	Risk
181	Sick	Sick	Urgent	431	Risk	Risk	Risk
182	Sick	Sick	Urgent	432	Risk	Risk	Risk
183	Sick	Sick	Urgent	433	Cold State	Risk	Risk
184	Sick	Sick	Urgent	434	Cold State	Risk	Risk
185	Sick	Sick	Urgent	435	Sick	Risk	Risk
186	Sick	Sick	Urgent	436	Sick	Risk	Risk
187	Sick	Sick	Urgent	437	Sick	Risk	Risk
188	Urgent	Sick	Urgent	438	Sick	Risk	Risk
189	Sick	Sick	Urgent	439	Sick	Risk	Risk
190	Sick	Sick	Urgent	440	Sick	Risk	Risk
191	Urgent	Sick	Urgent	441	Sick	Risk	Risk
192	Urgent	Sick	Urgent	442	Sick	Risk	Risk
193	Sick	Sick	Urgent	443	Sick	Risk	Risk
194	Sick	Sick	Urgent	444	Urgent	Risk	Risk
195	Sick	Sick	Urgent	445	Sick	Risk	Risk
196	Sick	Sick	Urgent	446	Sick	Risk	Risk
197	Sick	Sick	Urgent	447	Urgent	Risk	Risk
198	Sick	Sick	Urgent	448	Urgent	Risk	Risk
199	Sick	Sick	Urgent	449	Sick	Risk	Risk
200	Sick	Sick	Urgent	450	Sick	Risk	Risk
201	Sick	Sick	Urgent	451	Sick	Risk	Risk
202	Sick	Sick	Urgent	452	Sick	Risk	Risk
203	Urgent	Sick	Urgent	453	Sick	Risk	Risk
204	Urgent	Sick	Urgent	454	Sick	Risk	Risk
205	Sick	Sick	Urgent	455	Sick	Risk	Risk
206	Urgent	Sick	Urgent	456	Sick	Risk	Risk
207	Urgent	Sick	Urgent	457	Sick	Risk	Risk
208	Urgent	Sick	Urgent	458	Sick	Risk	Risk
209	Cold State	Normal	Normal	459	Urgent	Risk	Risk
210	Cold State	Normal	Normal	460	Urgent	Risk	Risk
211	Sick	Normal	Normal	461	Sick	Risk	Risk
212	Sick	Normal	Normal	462	Urgent	Risk	Risk
213	Cold State	Normal	Normal	463	Urgent	Risk	Risk
214	Cold State	Normal	Normal	464	Urgent	Risk	Risk
215	Sick	Normal	Normal	465	Cold State	Sick	Urgent
216	Sick	Normal	Normal	466	Cold State	Sick	Urgent
217	Sick	Normal	Normal	467	Sick	Sick	Urgent
218	Sick	Normal	Normal	468	Sick	Sick	Urgent
219	Sick	Normal	Normal	469	Cold State	Sick	Urgent
220	Sick	Normal	Normal	470	Cold State	Sick	Urgent
221	Sick	Normal	Normal	471	Sick	Sick	Urgent
222	Sick	Normal	Normal	472	Sick	Sick	Urgent
223	Sick	Normal	Normal	473	Sick	Sick	Urgent

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224	Urgent	Normal	Normal	474	Sick	Sick	Urgent
225	Cold State	Normal	Normal	475	Sick	Sick	Urgent
226	Cold State	Normal	Normal	476	Sick	Sick	Urgent
227	Sick	Normal	Normal	477	Sick	Sick	Urgent
228	Sick	Normal	Normal	478	Sick	Sick	Urgent
229	Sick	Normal	Normal	479	Sick	Sick	Urgent
230	Sick	Normal	Normal	480	Urgent	Sick	Urgent
231	Sick	Normal	Normal	481	Cold State	Sick	Urgent
232	Sick	Normal	Normal	482	Cold State	Sick	Urgent
233	Sick	Normal	Normal	483	Sick	Sick	Urgent
234	Sick	Normal	Normal	484	Sick	Sick	Urgent
235	Sick	Normal	Normal	485	Sick	Sick	Urgent
236	Urgent	Normal	Normal	486	Sick	Sick	Urgent
237	Sick	Normal	Normal	487	Sick	Sick	Urgent
238	Sick	Normal	Normal	488	Sick	Sick	Urgent
239	Urgent	Normal	Normal	489	Sick	Sick	Urgent
240	Urgent	Normal	Normal	490	Sick	Sick	Urgent
241	Sick	Normal	Normal	491	Sick	Sick	Urgent
242	Sick	Normal	Normal	492	Urgent	Sick	Urgent
243	Sick	Normal	Normal	493	Sick	Sick	Urgent
244	Sick	Normal	Normal	494	Sick	Sick	Urgent
245	Sick	Normal	Normal	495	Urgent	Sick	Urgent
246	Sick	Normal	Normal	496	Urgent	Sick	Urgent
247	Sick	Normal	Normal	497	Cold State	Normal	Normal
248	Sick	Normal	Normal	498	Cold State	Normal	Normal
249	Sick	Normal	Normal	499	Cold State	Normal	Normal
250	Sick	Normal	Normal	500	Cold State	Normal	Normal

TableC.2

05-4506832 pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

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The overall data alignment process for triage levels of MCDs results

P. No.	*CHD*	*HBPD*	*LBPD*	*p. No.*	*CHD*	*HBPD*	*LBPD*
1	2	4	4	251	3	0	0
2	2	4	4	252	3	0	0
3	2	4	4	253	2	0	0
4	2	4	4	254	3	0	0
5	2	4	4	255	3	0	0
6	2	4	4	256	3	0	0
7	2	4	4	257	2	2	3
8	3	4	4	258	2	2	3
9	2	4	4	259	2	2	3
10	3	4	4	260	2	2	3
11	3	4	4	261	2	2	3
12	3	4	4	262	2	2	3
13	3	4	4	263	2	2	3
14	3	4	4	264	3	2	3
15	4	4	4	265	2	2	3
16	4	4	4	266	3	2	3
17	2	4	4	267	3	2	3
18	2	4	4	268	3	2	3
19	2	4	4	269	3	2	3
20	3	4	4	270	3	2	3
21	2	4	4	271	4	2	3
22	2	4	4	272	4	2	3
23	3	4	4	273	2	4	4
24	3	4	4	274	2	4	4
25	3	4	4	275	2	4	4
26	3	4	4	276	3	4	4
27	4	4	4	277	2	4	4
28	4	4	4	278	2	4	4
29	3	4	4	279	3	4	4
30	3	4	4	280	3	4	4
31	4	4	4	281	3	4	4
32	4	4	4	282	3	4	4
33	2	2	3	283	4	4	4
34	2	2	3	284	4	4	4
35	2	2	3	285	3	4	4
36	2	2	3	286	3	4	4
37	2	2	3	287	4	4	4
38	2	2	3	288	4	4	4
39	2	2	3	289	2	4	4
40	2	2	3	290	2	4	4
41	2	2	3	291	2	4	4
42	2	2	3	292	2	4	4
43	3	2	3	293	2	4	4

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44	3	2	3	294	2	4	4
45	2	2	3	295	3	4	4
46	3	2	3	296	3	4	4
47	3	2	3	297	3	4	4
48	3	2	3	298	3	4	4
49	2	2	3	299	4	4	4
50	2	2	3	300	4	4	4
51	2	2	3	301	3	4	4
52	2	2	3	302	3	4	4
53	2	2	3	303	4	4	4
54	2	2	3	304	4	4	4
55	2	2	3	305	2	4	4
56	3	2	3	306	2	4	4
57	2	2	3	307	3	4	4
58	3	2	3	308	3	4	4
59	3	2	3	309	2	4	4
60	3	2	3	310	2	4	4
61	3	2	3	311	3	4	4
62	3	2	3	312	3	4	4
63	4	2	3	313	3	4	4
64	4	2	3	314	3	4	4
65	1	0	0	315	4	4	4
66	1	0	0	316	4	4	4
67	2	0	0	317	4	4	4
68	2	0	0	318	4	4	4
69	2	0	0	319	4	4	4
70	2	0	0	320	4	4	4
71	2	0	0	321	2	2	3
72	2	0	0	322	2	2	3
73	2	0	0	323	2	2	3
74	2	0	0	324	2	2	3
75	2	0	0	325	2	2	3
76	3	0	0	326	2	2	3
77	2	0	0	327	2	2	3
78	2	0	0	328	2	2	3
79	3	0	0	329	2	2	3
80	3	0	0	330	2	2	3
81	2	0	0	331	3	2	3
82	2	0	0	332	3	2	3
83	2	0	0	333	3	2	3
84	2	0	0	334	3	2	3
85	2	0	0	335	4	2	3
86	2	0	0	336	4	2	3
87	2	0	0	337	2	2	3
88	2	0	0	338	2	2	3
89	2	0	0	339	2	2	3

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90	2	0	0	340	2	2	3
91	3	0	0	341	2	2	3
92	3	0	0	342	2	2	3
93	2	0	0	343	3	2	3
94	3	0	0	344	3	2	3
95	3	0	0	345	3	2	3
96	3	0	0	346	3	2	3
97	2	0	0	347	4	2	3
98	2	0	0	348	4	2	3
99	2	0	0	349	3	2	3
100	2	0	0	350	3	2	3
101	2	0	0	351	4	2	3
102	2	0	0	352	4	2	3
103	2	0	0	353	1	0	0
104	3	0	0	354	2	0	0
105	2	0	0	355	2	0	0
106	3	0	0	356	2	0	0
107	3	0	0	357	2	0	0
108	3	0	0	358	2	0	0
109	3	0	0	359	2	0	0
110	3	0	0	360	2	0	0
111	4	0	0	361	2	0	0
112	4	0	0	362	2	0	0
113	2	2	3	363	3	0	0
114	2	2	3	364	3	0	0
115	2	2	3	365	2	0	0
116	3	2	3	366	2	0	0
117	2	2	3	367	3	0	0
118	2	2	3	368	3	0	0
119	3	2	3	369	2	0	0
120	3	2	3	370	2	0	0
121	3	2	3	371	2	0	0
122	3	2	3	372	2	0	0
123	4	2	3	373	2	0	0
124	4	2	3	374	2	0	0
125	3	2	3	375	2	0	0
126	3	2	3	376	2	0	0
127	4	2	3	377	2	0	0
128	4	2	3	378	2	0	0
129	2	4	4	379	3	0	0
130	2	4	4	380	3	0	0
131	3	4	4	381	3	0	0
132	3	4	4	382	3	0	0
133	2	4	4	383	4	0	0
134	3	4	4	384	4	0	0
135	3	4	4	385	2	0	0

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136	3	4	4	386	2	0	0
137	3	4	4	387	2	0	0
138	3	4	4	388	2	0	0
139	4	4	4	389	2	0	0
140	4	4	4	390	2	0	0
141	4	4	4	391	3	0	0
142	4	4	4	392	3	0	0
143	4	4	4	393	3	0	0
144	4	4	4	394	3	0	0
145	2	4	4	395	4	0	0
146	2	4	4	396	4	0	0
147	2	4	4	397	3	0	0
148	2	4	4	398	3	0	0
149	2	4	4	399	4	0	0
150	2	4	4	400	4	0	0
151	2	4	4	401	2	2	3
152	2	4	4	402	2	2	3
153	2	4	4	403	3	2	3
154	2	4	4	404	3	2	3
155	3	4	4	405	2	2	3
156	3	4	4	406	2	2	3
157	2	4	4	407	3	2	3
158	3	4	4	408	3	2	3
159	3	4	4	409	3	2	3
160	3	4	4	410	3	2	3
161	2	4	4	411	4	2	3
162	2	4	4	412	4	2	3
163	2	4	4	413	4	2	3
164	2	4	4	414	4	2	3
165	2	4	4	415	4	2	3
166	2	4	4	416	4	2	3
167	2	4	4	417	2	4	4
168	3	4	4	418	2	4	4
169	2	4	4	419	3	4	4
170	3	4	4	420	3	4	4
171	3	4	4	421	3	4	4
172	3	4	4	422	3	4	4
173	3	4	4	423	4	4	4
174	3	4	4	424	4	4	4
175	4	4	4	425	4	4	4
176	4	4	4	426	4	4	4
177	1	2	3	427	4	4	4
178	1	2	3	428	4	4	4
179	2	2	3	429	4	4	4
180	2	2	3	430	4	4	4
181	2	2	3	431	4	4	4

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182	2	2	3	432	4	4	4
183	2	2	3	433	1	4	4
184	2	2	3	434	1	4	4
185	2	2	3	435	2	4	4
186	2	2	3	436	2	4	4
187	2	2	3	437	2	4	4
188	3	2	3	438	2	4	4
189	2	2	3	439	2	4	4
190	2	2	3	440	2	4	4
191	3	2	3	441	2	4	4
192	3	2	3	442	2	4	4
193	2	2	3	443	2	4	4
194	2	2	3	444	3	4	4
195	2	2	3	445	2	4	4
196	2	2	3	446	2	4	4
197	2	2	3	447	3	4	4
198	2	2	3	448	3	4	4
199	2	2	3	449	2	4	4
200	2	2	3	450	2	4	4
201	2	2	3	451	2	4	4
202	2	2	3	452	2	4	4
203	3	2	3	453	2	4	4
204	3	2	3	454	2	4	4
205	2	2	3	455	2	4	4
206	3	2	3	456	2	4	4
207	3	2	3	457	2	4	4
208	3	2	3	458	2	4	4
209	1	0	0	459	3	4	4
210	1	0	0	460	3	4	4
211	2	0	0	461	2	4	4
212	2	0	0	462	3	4	4
213	1	0	0	463	3	4	4
214	1	0	0	464	3	4	4
215	2	0	0	465	1	2	3
216	2	0	0	466	1	2	3
217	2	0	0	467	2	2	3
218	2	0	0	468	2	2	3
219	2	0	0	469	1	2	3
220	2	0	0	470	1	2	3
221	2	0	0	471	2	2	3
222	2	0	0	472	2	2	3
223	2	0	0	473	2	2	3
224	3	0	0	474	2	2	3
225	1	0	0	475	2	2	3
226	1	0	0	476	2	2	3
227	2	0	0	477	2	2	3

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228	2	0	0	478	2	2	3
229	2	0	0	479	2	2	3
230	2	0	0	480	3	2	3
231	2	0	0	481	1	2	3
232	2	0	0	482	1	2	3
233	2	0	0	483	2	2	3
234	2	0	0	484	2	2	3
235	2	0	0	485	2	2	3
236	3	0	0	486	2	2	3
237	2	0	0	487	2	2	3
238	2	0	0	488	2	2	3
239	3	0	0	489	2	2	3
240	3	0	0	490	2	2	3
241	2	0	0	491	2	2	3
242	2	0	0	492	3	2	3
243	2	0	0	493	2	2	3
244	2	0	0	494	2	2	3
245	2	0	0	495	3	2	3
246	2	0	0	496	3	2	3
247	2	0	0	497	1	0	0
248	2	0	0	498	1	0	0
249	2	0	0	499	1	0	0
250	2	0	0	500	1	0	0

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Appendix (D)

Table D.1
The overall matching between each patient triage and validated rules

P. No.	HBPD	LBPD	CHD	Rules	P. No.	HBPD	LBPD	CHD	Rules
1	4	4	2	R3	251	0	0	3	R122
2	4	4	2	R3	252	0	0	3	R122
3	4	4	2	R3	253	0	0	2	R123
4	4	4	2	R3	254	0	0	3	R122
5	4	4	2	R3	255	0	0	3	R122
6	4	4	2	R3	256	0	0	3	R122
7	4	4	2	R3	257	2	3	2	R58
8	4	4	3	R2	258	2	3	2	R58
9	4	4	2	R3	259	2	3	2	R58
10	4	4	3	R2	260	2	3	2	R58
11	4	4	3	R2	261	2	3	2	R58
12	4	4	3	R2	262	2	3	2	R58
13	4	4	3	R2	263	2	3	2	R58
14	4	4	3	R2	264	2	3	3	R57
15	4	4	4	R1	265	2	3	2	R58
16	4	4	4	R1	266	2	3	3	R57
17	4	4	2	R3	267	2	3	3	R57
18	4	4	2	R3	268	2	3	3	R57
19	4	4	2	R3	269	2	3	3	R57
20	4	4	3	R2	270	2	3	3	R57
21	4	4	2	R3	271	2	3	4	R56
22	4	4	2	R3	272	2	3	4	R56
23	4	4	3	R2	273	4	4	2	R3
24	4	4	3	R2	274	4	4	2	R3
25	4	4	3	R2	275	4	4	2	R3
26	4	4	3	R2	276	4	4	3	R2
27	4	4	4	R1	277	4	4	2	R3
28	4	4	4	R1	278	4	4	2	R3
29	4	4	3	R2	279	4	4	3	R2
30	4	4	3	R2	280	4	4	3	R2
31	4	4	4	R1	281	4	4	3	R2
32	4	4	4	R1	282	4	4	3	R2
33	2	3	2	R58	283	4	4	4	R1
34	2	3	2	R58	284	4	4	4	R1
35	2	3	2	R58	285	4	4	3	R2
36	2	3	2	R58	286	4	4	3	R2
37	2	3	2	R58	287	4	4	4	R1
38	2	3	2	R58	288	4	4	4	R1
39	2	3	2	R58	289	4	4	2	R3
40	2	3	2	R58	290	4	4	2	R3

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41	2	3	2	R58	291	4	4	2	R3
42	2	3	2	R58	292	4	4	2	R3
43	2	3	3	R57	293	4	4	2	R3
44	2	3	3	R57	294	4	4	2	R3
45	2	3	2	R58	295	4	4	3	R2
46	2	3	3	R57	296	4	4	3	R2
47	2	3	3	R57	297	4	4	3	R2
48	2	3	3	R57	298	4	4	3	R2
49	2	3	2	R58	299	4	4	4	R1
50	2	3	2	R58	300	4	4	4	R1
51	2	3	2	R58	301	4	4	3	R2
52	2	3	2	R58	302	4	4	3	R2
53	2	3	2	R58	303	4	4	4	R1
54	2	3	2	R58	304	4	4	4	R1
55	2	3	2	R58	305	4	4	2	R3
56	2	3	3	R57	306	4	4	2	R3
57	2	3	2	R58	307	4	4	3	R2
58	2	3	3	R57	308	4	4	3	R2
59	2	3	3	R57	309	4	4	2	R3
60	2	3	3	R57	310	4	4	2	R3
61	2	3	3	R57	311	4	4	3	R2
62	2	3	3	R57	312	4	4	3	R2
63	2	3	4	R56	313	4	4	3	R2
64	2	3	4	R56	314	4	4	3	R2
65	0	0	1	R124	315	4	4	4	R1
66	0	0	1	R124	316	4	4	4	R1
67	0	0	2	R123	317	4	4	4	R1
68	0	0	2	R123	318	4	4	4	R1
69	0	0	2	R123	319	4	4	4	R1
70	0	0	2	R123	320	4	4	4	R1
71	0	0	2	R123	321	2	3	2	R58
72	0	0	2	R123	322	2	3	2	R58
73	0	0	2	R123	323	2	3	2	R58
74	0	0	2	R123	324	2	3	2	R58
75	0	0	2	R123	325	2	3	2	R58
76	0	0	3	R122	326	2	3	2	R58
77	0	0	2	R123	327	2	3	2	R58
78	0	0	2	R123	328	2	3	2	R58
79	0	0	3	R122	329	2	3	2	R58
80	0	0	3	R122	330	2	3	2	R58
81	0	0	2	R123	331	2	3	3	R57
82	0	0	2	R123	332	2	3	3	R57
83	0	0	2	R123	333	2	3	3	R57
84	0	0	2	R123	334	2	3	3	R57
85	0	0	2	R123	335	2	3	4	R56
86	0	0	2	R123	336	2	3	4	R56

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87	0	0	2	R123	337	2	3	2	R58
88	0	0	2	R123	338	2	3	2	R58
89	0	0	2	R123	339	2	3	2	R58
90	0	0	2	R123	340	2	3	2	R58
91	0	0	3	R122	341	2	3	2	R58
92	0	0	3	R122	342	2	3	2	R58
93	0	0	2	R123	343	2	3	3	R57
94	0	0	3	R122	344	2	3	3	R57
95	0	0	3	R122	345	2	3	3	R57
96	0	0	3	R122	346	2	3	3	R57
97	0	0	2	R123	347	2	3	4	R56
98	0	0	2	R123	348	2	3	4	R56
99	0	0	2	R123	349	2	3	3	R57
100	0	0	2	R123	350	2	3	3	R57
101	0	0	2	R123	351	2	3	4	R56
102	0	0	2	R123	352	2	3	4	R56
103	0	0	2	R123	353	0	0	1	R124
104	0	0	3	R122	354	0	0	2	R123
105	0	0	2	R123	355	0	0	2	R123
106	0	0	3	R122	356	0	0	2	R123
107	0	0	3	R122	357	0	0	2	R123
108	0	0	3	R122	358	0	0	2	R123
109	0	0	3	R122	359	0	0	2	R123
110	0	0	3	R122	360	0	0	2	R123
111	0	0	4	R121	361	0	0	2	R123
112	0	0	4	R121	362	0	0	2	R123
113	2	3	2	R58	363	0	0	3	R122
114	2	3	2	R58	364	0	0	3	R122
115	2	3	2	R58	365	0	0	2	R123
116	2	3	3	R57	366	0	0	2	R123
117	2	3	2	R58	367	0	0	3	R122
118	2	3	2	R58	368	0	0	3	R122
119	2	3	3	R57	369	0	0	2	R123
120	2	3	3	R57	370	0	0	2	R123
121	2	3	3	R57	371	0	0	2	R123
122	2	3	3	R57	372	0	0	2	R123
123	2	3	4	R56	373	0	0	2	R123
124	2	3	4	R56	374	0	0	2	R123
125	2	3	3	R57	375	0	0	2	R123
126	2	3	3	R57	376	0	0	2	R123
127	2	3	4	R56	377	0	0	2	R123
128	2	3	4	R56	378	0	0	2	R123
129	4	4	2	R3	379	0	0	3	R122
130	4	4	2	R3	380	0	0	3	R122
131	4	4	3	R2	381	0	0	3	R122
132	4	4	3	R2	382	0	0	3	R122

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133	4	4	2	R3	383	0	0	4	R121
134	4	4	3	R2	384	0	0	4	R121
135	4	4	3	R2	385	0	0	2	R123
136	4	4	3	R2	386	0	0	2	R123
137	4	4	3	R2	387	0	0	2	R123
138	4	4	3	R2	388	0	0	2	R123
139	4	4	4	R1	389	0	0	2	R123
140	4	4	4	R1	390	0	0	2	R123
141	4	4	4	R1	391	0	0	3	R122
142	4	4	4	R1	392	0	0	3	R122
143	4	4	4	R1	393	0	0	3	R122
144	4	4	4	R1	394	0	0	3	R122
145	4	4	2	R3	395	0	0	4	R121
146	4	4	2	R3	396	0	0	4	R121
147	4	4	2	R3	397	0	0	3	R122
148	4	4	2	R3	398	0	0	3	R122
149	4	4	2	R3	399	0	0	4	R121
150	4	4	2	R3	400	0	0	4	R121
151	4	4	2	R3	401	2	3	2	R58
152	4	4	2	R3	402	2	3	2	R58
153	4	4	2	R3	403	2	3	3	R57
154	4	4	2	R3	404	2	3	3	R57
155	4	4	3	R2	405	2	3	2	R58
156	4	4	3	R2	406	2	3	2	R58
157	4	4	2	R3	407	2	3	3	R57
158	4	4	3	R2	408	2	3	3	R57
159	4	4	3	R2	409	2	3	3	R57
160	4	4	3	R2	410	2	3	3	R57
161	4	4	2	R3	411	2	3	4	R56
162	4	4	2	R3	412	2	3	4	R56
163	4	4	2	R3	413	2	3	4	R56
164	4	4	2	R3	414	2	3	4	R56
165	4	4	2	R3	415	2	3	4	R56
166	4	4	2	R3	416	2	3	4	R56
167	4	4	2	R3	417	4	4	2	R3
168	4	4	3	R2	418	4	4	2	R3
169	4	4	2	R3	419	4	4	3	R2
170	4	4	3	R2	420	4	4	3	R2
171	4	4	3	R2	421	4	4	3	R2
172	4	4	3	R2	422	4	4	3	R2
173	4	4	3	R2	423	4	4	4	R1
174	4	4	3	R2	424	4	4	4	R1
175	4	4	4	R1	425	4	4	4	R1
176	4	4	4	R1	426	4	4	4	R1
177	2	3	1	R59	427	4	4	4	R1
178	2	3	1	R59	428	4	4	4	R1

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179	2	3	2	R58	429	4	4	4	R1
180	2	3	2	R58	430	4	4	4	R1
181	2	3	2	R58	431	4	4	4	R1
182	2	3	2	R58	432	4	4	4	R1
183	2	3	2	R58	433	4	4	1	R4
184	2	3	2	R58	434	4	4	1	R4
185	2	3	2	R58	435	4	4	2	R3
186	2	3	2	R58	436	4	4	2	R3
187	2	3	2	R58	437	4	4	2	R3
188	2	3	3	R57	438	4	4	2	R3
189	2	3	2	R58	439	4	4	2	R3
190	2	3	2	R58	440	4	4	2	R3
191	2	3	3	R57	441	4	4	2	R3
192	2	3	3	R57	442	4	4	2	R3
193	2	3	2	R58	443	4	4	2	R3
194	2	3	2	R58	444	4	4	3	R2
195	2	3	2	R58	445	4	4	2	R3
196	2	3	2	R58	446	4	4	2	R3
197	2	3	2	R58	447	4	4	3	R2
198	2	3	2	R58	448	4	4	3	R2
199	2	3	2	R58	449	4	4	2	R3
200	2	3	2	R58	450	4	4	2	R3
201	2	3	2	R58	451	4	4	2	R3
202	2	3	2	R58	452	4	4	2	R3
203	2	3	3	R57	453	4	4	2	R3
204	2	3	3	R57	454	4	4	2	R3
205	2	3	2	R58	455	4	4	2	R3
206	2	3	3	R57	456	4	4	2	R3
207	2	3	3	R57	457	4	4	2	R3
208	2	3	3	R57	458	4	4	2	R3
209	0	0	1	R124	459	4	4	3	R2
210	0	0	1	R124	460	4	4	3	R2
211	0	0	2	R123	461	4	4	2	R3
212	0	0	2	R123	462	4	4	3	R2
213	0	0	1	R124	463	4	4	3	R2
214	0	0	1	R124	464	4	4	3	R2
215	0	0	2	R123	465	2	3	1	R59
216	0	0	2	R123	466	2	3	1	R59
217	0	0	2	R123	467	2	3	2	R58
218	0	0	2	R123	468	2	3	2	R58
219	0	0	2	R123	469	2	3	1	R59
220	0	0	2	R123	470	2	3	1	R59
221	0	0	2	R123	471	2	3	2	R58
222	0	0	2	R123	472	2	3	2	R58
223	0	0	2	R123	473	2	3	2	R58
224	0	0	3	R122	474	2	3	2	R58

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225	0	0	1	R124	475	2	3	2	R58
226	0	0	1	R124	476	2	3	2	R58
227	0	0	2	R123	477	2	3	2	R58
228	0	0	2	R123	478	2	3	2	R58
229	0	0	2	R123	479	2	3	2	R58
230	0	0	2	R123	480	2	3	3	R57
231	0	0	2	R123	481	2	3	1	R59
232	0	0	2	R123	482	2	3	1	R59
233	0	0	2	R123	483	2	3	2	R58
234	0	0	2	R123	484	2	3	2	R58
235	0	0	2	R123	485	2	3	2	R58
236	0	0	3	R122	486	2	3	2	R58
237	0	0	2	R123	487	2	3	2	R58
238	0	0	2	R123	488	2	3	2	R58
239	0	0	3	R122	489	2	3	2	R58
240	0	0	3	R122	490	2	3	2	R58
241	0	0	2	R123	491	2	3	2	R58
242	0	0	2	R123	492	2	3	3	R57
243	0	0	2	R123	493	2	3	2	R58
244	0	0	2	R123	494	2	3	2	R58
245	0	0	2	R123	495	2	3	3	R57
246	0	0	2	R123	496	2	3	3	R57
247	0	0	2	R123	497	0	0	1	R124
248	0	0	2	R123	498	0	0	1	R124
249	0	0	2	R123	499	0	0	1	R124
250	0	0	2	R123	500	0	0	1	R124

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Appendix (E)

Table E.1

Decision matrix for patients within rule 2

P. No.	HBPD	LBPD	Spo2	BP	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	ST El.
8	4	4	0	4	0	1	1	1	0	0	0	0
10	4	4	0	4	1	0	0	1	0	0	0	0
11	4	4	0	4	1	0	1	0	0	0	0	0
12	4	4	0	4	1	0	1	1	0	0	0	0
13	4	4	0	4	1	1	0	0	0	0	0	0
14	4	4	0	4	1	1	0	1	0	0	0	0
20	4	4	1	4	0	0	1	1	0	0	0	0
23	4	4	1	4	0	1	1	0	0	0	0	0
24	4	4	1	4	0	1	1	1	0	0	0	0
25	4	4	1	4	1	0	0	0	0	0	0	0
26	4	4	1	4	1	0	0	1	0	0	0	0
29	4	4	1	4	1	1	0	0	0	0	0	0
30	4	4	1	4	1	1	0	1	0	0	0	0
131	4	4	2	4	0	0	1	0	0	0	0	0
132	4	4	2	4	0	0	1	1	0	0	0	0
134	4	4	2	4	0	1	0	1	0	0	0	0
135	4	4	2	4	0	1	1	0	0	0	0	0
136	4	4	2	4	0	1	1	1	0	0	0	0
137	4	4	2	4	1	0	0	0	0	0	0	0
138	4	4	2	4	1	0	0	1	0	0	0	0
155	4	4	0	4	1	0	1	0	1	1	0	1
156	4	4	0	4	1	0	1	1	1	1	0	1
158	4	4	0	4	1	1	0	1	1	1	0	1
159	4	4	0	4	1	1	1	0	1	1	0	1
160	4	4	0	4	1	1	1	1	1	1	0	1
168	4	4	1	4	0	1	1	1	1	1	0	1
170	4	4	1	4	1	0	0	1	1	1	0	1
171	4	4	1	4	1	0	1	0	1	1	0	1
172	4	4	1	4	1	0	1	1	1	1	0	1
173	4	4	1	4	1	1	0	0	1	1	0	1
174	4	4	1	4	1	1	0	1	1	1	0	1
276	4	4	2	4	0	0	1	1	1	1	0	1
279	4	4	2	4	0	1	1	0	1	1	0	1
280	4	4	2	4	0	1	1	1	1	1	0	1
281	4	4	2	4	1	0	0	0	1	1	0	1
282	4	4	2	4	1	0	0	1	1	1	0	1
285	4	4	2	4	1	1	0	0	1	1	0	1
286	4	4	2	4	1	1	0	1	1	1	0	1
295	4	4	0	4	0	1	1	0	0	0	1	0

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296	4	4	0	4	0	1	1	1	0	0	1	0
297	4	4	0	4	1	0	0	0	0	0	1	0
298	4	4	0	4	1	0	0	1	0	0	1	0
301	4	4	0	4	1	1	0	0	0	0	1	0
302	4	4	0	4	1	1	0	1	0	0	1	0
307	4	4	1	4	0	0	1	0	0	0	1	0
308	4	4	1	4	0	0	1	1	0	0	1	0
311	4	4	1	4	0	1	1	0	0	0	1	0
312	4	4	1	4	0	1	1	1	0	0	1	0
313	4	4	1	4	1	0	0	0	0	0	1	0
314	4	4	1	4	1	0	0	1	0	0	1	0
419	4	4	2	4	0	0	1	0	0	0	1	0
420	4	4	2	4	0	0	1	1	0	0	1	0
421	4	4	2	4	0	1	0	0	0	0	1	0
422	4	4	2	4	0	1	0	1	0	0	1	0
444	4	4	0	4	1	0	1	1	0	0	1	1
447	4	4	0	4	1	1	1	0	0	0	1	1
448	4	4	0	4	1	1	1	1	0	0	1	1
459	4	4	1	4	1	0	1	0	0	0	1	1
460	4	4	1	4	1	0	1	1	0	0	1	1
462	4	4	1	4	1	1	0	1	0	0	1	1
463	4	4	1	4	1	1	1	0	0	0	1	1
464	4	4	1	4	1	1	1	1	0	0	1	1

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Table E.2

Decision matrix for patients within rule 3

P. No.	HBPD	LBPD	Spo2	BP	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	ST El.
1	4	4	0	4	0	0	0	0	0	0	0	0
2	4	4	0	4	0	0	0	1	0	0	0	0
3	4	4	0	4	0	0	1	0	0	0	0	0
4	4	4	0	4	0	0	1	1	0	0	0	0
5	4	4	0	4	0	1	0	0	0	0	0	0
6	4	4	0	4	0	1	0	1	0	0	0	0
7	4	4	0	4	0	1	1	0	0	0	0	0
9	4	4	0	4	1	0	0	0	0	0	0	0
17	4	4	1	4	0	0	0	0	0	0	0	0
18	4	4	1	4	0	0	0	1	0	0	0	0
19	4	4	1	4	0	0	1	0	0	0	0	0
21	4	4	1	4	0	1	0	0	0	0	0	0
22	4	4	1	4	0	1	0	1	0	0	0	0
129	4	4	2	3	0	0	0	0	0	0	0	0
130	4	4	2	3	0	0	0	1	0	0	0	0
133	4	4	2	4	0	1	0	0	0	0	0	0

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145	4	4	0	4	0	0	0	0	1	1	0	1
146	4	4	0	4	0	0	0	1	1	1	0	1
147	4	4	0	4	0	0	1	0	1	1	0	1
148	4	4	0	4	0	0	1	1	1	1	0	1
149	4	4	0	4	0	1	0	0	1	1	0	1
150	4	4	0	4	0	1	0	1	1	1	0	1
151	4	4	0	4	0	1	1	0	1	1	0	1
152	4	4	0	4	0	1	1	1	1	1	0	1
153	4	4	0	4	1	0	0	0	1	1	0	1
154	4	4	0	4	1	0	0	1	1	1	0	1
157	4	4	0	4	1	1	0	0	1	1	0	1
161	4	4	1	4	0	0	0	0	1	1	0	1
162	4	4	1	4	0	0	0	1	1	1	0	1
163	4	4	1	4	0	0	1	0	1	1	0	1
164	4	4	1	4	0	0	1	1	1	1	0	1
165	4	4	1	4	0	1	0	0	1	1	0	1
166	4	4	1	4	0	1	0	1	1	1	0	1
167	4	4	1	4	0	1	1	0	1	1	0	1
169	4	4	1	4	1	0	0	0	1	1	0	1
273	4	4	2	4	0	0	0	0	1	1	0	1
274	4	4	2	4	0	0	0	1	1	1	0	1
275	4	4	2	4	0	0	1	0	1	1	0	1
277	4	4	2	4	0	1	0	0	1	1	0	1
278	4	4	2	4	0	1	0	1	1	1	0	1
289	4	4	0	4	0	0	0	0	0	0	1	0
290	4	4	0	4	0	0	0	1	0	0	1	0
291	4	4	0	4	0	0	1	0	0	0	1	0
292	4	4	0	4	0	0	1	1	0	0	1	0
293	4	4	0	4	0	1	0	0	0	0	1	0
294	4	4	0	4	0	1	0	1	0	0	1	0
305	4	4	1	4	0	0	0	0	0	0	1	0
306	4	4	1	4	0	0	0	1	0	0	1	0
309	4	4	1	4	0	1	0	0	0	0	1	0
310	4	4	1	4	0	1	0	1	0	0	1	0
417	4	4	2	4	0	0	0	0	0	0	1	0
418	4	4	2	4	0	0	0	1	0	0	1	0
435	4	4	0	4	0	0	1	0	0	0	1	1
436	4	4	0	4	0	0	1	1	0	0	1	1
437	4	4	0	4	0	1	0	0	0	0	1	1
438	4	4	0	4	0	1	0	1	0	0	1	1
439	4	4	0	4	0	1	1	0	0	0	1	1
440	4	4	0	4	0	1	1	1	0	0	1	1
441	4	4	0	4	1	0	0	0	0	0	1	1
442	4	4	0	4	1	0	0	1	0	0	1	1
443	4	4	0	4	1	0	1	0	0	0	1	1
445	4	4	0	4	1	1	0	0	0	0	1	1

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446	4	4	0	4	1	1	0	1	0	0	1	1
449	4	4	1	4	0	0	0	0	0	0	1	1
450	4	4	1	4	0	0	0	1	0	0	1	1
451	4	4	1	4	0	0	1	0	0	0	1	1
452	4	4	1	4	0	0	1	1	0	0	1	1
453	4	4	1	4	0	1	0	0	0	0	1	1
454	4	4	1	4	0	1	0	1	0	0	1	1
455	4	4	1	4	0	1	1	0	0	0	1	1
456	4	4	1	4	0	1	1	1	0	0	1	1
457	4	4	1	4	1	0	0	0	0	0	1	1
458	4	4	1	4	1	0	0	1	0	0	1	1
461	4	4	1	4	1	1	0	0	0	0	1	1

Table E.3

Decision matrix for patients within rule 4

P. No.	*HBPD*	*LBPD*	*Spo2*	*BP*	*Chest Pain*	*SH. Breath.*	*Palip.*	*rest?*	*Peaks*	*QRS width*	*P-P*	*ST EL*
433	4	4	0	4	0	0	0	0	0	0	1	1
434	4	4	0	4	0	0	0	1	0	0	1	1

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Table E.4

Decision matrix for patients within rule 56

P. No.	*HBPD*	*LBPD*	*Spo2*	*BP*	*Chest Pain*	*SH. Breath.*	*Palip.*	*rest?*	*Peaks*	*QRS width*	*P-P*	*ST EL*
63	2	3	1	3	1	1	1	0	0	0	0	0
64	2	3	1	3	1	1	1	1	0	0	0	0
123	2	3	2	3	1	0	1	0	0	0	0	0
124	2	3	2	3	1	0	1	1	0	0	0	0
127	2	3	2	3	1	1	1	0	0	0	0	0
128	2	3	2	3	1	1	1	1	0	0	0	0
271	2	3	2	3	1	1	1	0	1	1	0	1
272	2	3	2	3	1	1	1	1	1	1	0	1
335	2	3	0	3	1	1	1	0	0	0	1	0
336	2	3	0	3	1	1	1	1	0	0	1	0
347	2	3	1	3	1	0	1	0	0	0	1	0
348	2	3	1	3	1	0	1	1	0	0	1	0
351	2	3	1	3	1	1	1	0	0	0	1	0
352	2	3	1	3	1	1	1	1	0	0	1	0
411	2	3	2	3	1	0	1	0	0	0	1	0
412	2	3	2	3	1	0	1	1	0	0	1	0
413	2	3	2	3	1	1	0	0	0	0	1	0

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414	2	3	2	3	1	1	0	1	0	0	1	0
415	2	3	2	3	1	1	1	0	0	0	1	0
416	2	3	2	3	1	1	1	1	0	0	1	0

Table E.5

Decision matrix for patients within rule 121

P. No.	*HBPD*	*LBPD*	*Spo2*	*BP*	*Chest Pain*	*SH. Breath.*	*Palip.*	*rest?*	*Peaks*	*QRS width*	*P-P*	*ST EL*
111	0	0	2	0	1	1	1	0	0	0	0	0
112	0	0	2	0	1	1	1	1	0	0	0	0
383	0	0	1	0	1	1	1	0	0	0	1	0
384	0	0	1	0	1	1	1	1	0	0	1	0
395	0	0	2	0	1	0	1	0	0	0	1	0
396	0	0	2	0	1	0	1	1	0	0	1	0
399	0	0	2	0	1	1	1	0	0	0	1	0
400	0	0	2	0	1	1	1	1	0	0	1	0

Table E.6

Decision matrix for patients within rule 57

P. No.	*HBPD*	*LBPD*	*Spo2*	*BP*	*Chest Pain*	*SH. Breath.*	*Palip.*	*rest?*	*Peaks*	*QRS width*	*P-P*	*ST EL*
43	2	3	0	3	1	0	1	0	0	0	0	0
44	2	3	0	3	1	0	1	1	0	0	0	0
46	2	3	0	3	1	1	0	1	0	0	0	0
47	2	3	0	3	1	1	1	0	0	0	0	0
48	2	3	0	3	1	1	1	1	0	0	0	0
56	2	3	1	3	0	1	1	1	0	0	0	0
58	2	3	1	3	1	0	0	1	0	0	0	0
59	2	3	1	3	1	0	1	0	0	0	0	0
60	2	3	1	3	1	0	1	1	0	0	0	0
61	2	3	1	3	1	1	0	0	0	0	0	0
62	2	3	1	3	1	1	0	1	0	0	0	0
116	2	3	2	3	0	0	1	1	0	0	0	0
119	2	3	2	3	0	1	1	0	0	0	0	0
120	2	3	2	3	0	1	1	1	0	0	0	0
121	2	3	2	3	1	0	0	0	0	0	0	0
122	2	3	2	3	1	0	0	1	0	0	0	0
125	2	3	2	3	1	1	0	0	0	0	0	0
126	2	3	2	3	1	1	0	1	0	0	0	0
188	2	3	0	3	1	0	1	1	1	1	0	1
191	2	3	0	3	1	1	1	0	1	1	0	1

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192	2	3	0	3	1	1	1	1	1	1	0	1
203	2	3	1	3	1	0	1	0	1	1	0	1
204	2	3	1	3	1	0	1	1	1	1	0	1
206	2	3	1	3	1	1	0	1	1	1	0	1
207	2	3	1	3	1	1	1	0	1	1	0	1
208	2	3	1	3	1	1	1	1	1	1	0	1
264	2	3	2	3	0	1	1	1	1	1	0	1
266	2	3	2	3	1	0	0	1	1	1	0	1
267	2	3	2	3	1	0	1	0	1	1	0	1
268	2	3	2	3	1	0	1	1	1	1	0	1
269	2	3	2	3	1	1	0	0	1	1	0	1
270	2	3	2	3	1	1	0	1	1	1	0	1
331	2	3	0	3	1	0	1	0	0	0	1	0
332	2	3	0	3	1	0	1	1	0	0	1	0
333	2	3	0	3	1	1	0	0	0	0	1	0
334	2	3	0	3	1	1	0	1	0	0	1	0
343	2	3	1	3	0	1	1	0	0	0	1	0
344	2	3	1	3	0	1	1	1	0	0	1	0
345	2	3	1	3	1	0	0	0	0	0	1	0
346	2	3	1	3	1	0	0	1	0	0	1	0
349	2	3	1	3	1	1	0	0	0	0	1	0
350	2	3	1	3	1	1	0	1	0	0	1	0
403	2	3	2	3	0	0	1	0	0	0	1	0
404	2	3	2	3	0	0	1	1	0	0	1	0
407	2	3	2	3	0	1	1	0	0	0	1	0
408	2	3	2	3	0	1	1	1	0	0	1	0
409	2	3	2	3	1	0	0	0	0	0	1	0
410	2	3	2	3	1	0	0	1	0	0	1	0
480	2	3	0	3	1	1	1	1	0	0	1	1
492	2	3	1	3	1	0	1	1	0	0	1	1
495	2	3	1	3	1	1	1	0	0	0	1	1
496	2	3	1	3	1	1	1	1	0	0	1	1

Table E.7

Decision matrix for patients within rule 58

P. No.	HBPD	LBPD	Spo2	BP	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	ST El.
33	2	3	0	3	0	0	0	0	0	0	0	0
34	2	3	0	3	0	0	0	1	0	0	0	0
35	2	3	0	3	0	0	1	0	0	0	0	0
36	2	3	0	3	0	0	1	1	0	0	0	0
37	2	3	0	3	0	1	0	0	0	0	0	0
38	2	3	0	3	0	1	0	1	0	0	0	0

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39	2	3	0	3	0	1	1	0	0	0	0	0
40	2	3	0	3	0	1	1	1	0	0	0	0
41	2	3	0	3	1	0	0	0	0	0	0	0
42	2	3	0	3	1	0	0	1	0	0	0	0
45	2	3	0	3	1	1	0	0	0	0	0	0
49	2	3	1	3	0	0	0	0	0	0	0	0
50	2	3	1	3	0	0	0	1	0	0	0	0
51	2	3	1	3	0	0	1	0	0	0	0	0
52	2	3	1	3	0	0	1	1	0	0	0	0
53	2	3	1	3	0	1	0	0	0	0	0	0
54	2	3	1	3	0	1	0	1	0	0	0	0
55	2	3	1	3	0	1	1	0	0	0	0	0
57	2	3	1	3	1	0	0	0	0	0	0	0
113	2	3	2	0	0	0	0	0	0	0	0	0
114	2	3	2	0	0	0	0	1	0	0	0	0
115	2	3	2	3	0	0	1	0	0	0	0	0
117	2	3	2	3	0	1	0	0	0	0	0	0
118	2	3	2	3	0	1	0	1	0	0	0	0
179	2	3	0	3	0	0	1	0	1	1	0	1
180	2	3	0	3	0	0	1	1	1	1	0	1
181	2	3	0	3	0	1	0	0	1	1	0	1
182	2	3	0	3	0	1	0	1	1	1	0	1
183	2	3	0	3	0	1	1	0	1	1	0	1
184	2	3	0	3	0	1	1	1	1	1	0	1
185	2	3	0	3	1	0	0	0	1	1	0	1
186	2	3	0	3	1	0	0	1	1	1	0	1
187	2	3	0	3	1	0	1	0	1	1	0	1
189	2	3	0	3	1	1	0	0	1	1	0	1
190	2	3	0	3	1	1	0	1	1	1	0	1
193	2	3	1	3	0	0	0	0	1	1	0	1
194	2	3	1	3	0	0	0	1	1	1	0	1
195	2	3	1	3	0	0	1	0	1	1	0	1
196	2	3	1	3	0	0	1	1	1	1	0	1
197	2	3	1	3	0	1	0	0	1	1	0	1
198	2	3	1	3	0	1	0	1	1	1	0	1
199	2	3	1	3	0	1	1	0	1	1	0	1
200	2	3	1	3	0	1	1	1	1	1	0	1
201	2	3	1	3	1	0	0	0	1	1	0	1
202	2	3	1	3	1	0	0	1	1	1	0	1
205	2	3	1	3	1	1	0	0	1	1	0	1
257	2	3	2	3	0	0	0	0	1	1	0	1
258	2	3	2	3	0	0	0	1	1	1	0	1
259	2	3	2	3	0	0	1	0	1	1	0	1
260	2	3	2	3	0	0	1	1	1	1	0	1
261	2	3	2	3	0	1	0	0	1	1	0	1
262	2	3	2	3	0	1	0	1	1	1	0	1

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263	2	3	2	3	0	1	1	0	1	1	0	1
265	2	3	2	3	1	0	0	0	1	1	0	1
321	2	3	0	3	0	0	0	0	0	0	1	0
322	2	3	0	3	0	0	0	1	0	0	1	0
323	2	3	0	3	0	0	1	0	0	0	1	0
324	2	3	0	3	0	0	1	1	0	0	1	0
325	2	3	0	3	0	1	0	0	0	0	1	0
326	2	3	0	3	0	1	0	1	0	0	1	0
327	2	3	0	3	0	1	1	0	0	0	1	0
328	2	3	0	3	0	1	1	1	0	0	1	0
329	2	3	0	3	1	0	0	0	0	0	1	0
330	2	3	0	3	1	0	0	1	0	0	1	0
337	2	3	1	3	0	0	0	0	0	0	1	0
338	2	3	1	3	0	0	0	1	0	0	1	0
339	2	3	1	3	0	0	1	0	0	0	1	0
340	2	3	1	3	0	0	1	1	0	0	1	0
341	2	3	1	3	0	1	0	0	0	0	1	0
342	2	3	1	3	0	1	0	1	0	0	1	0
401	2	3	2	3	0	0	0	0	0	0	1	0
402	2	3	2	3	0	0	0	1	0	0	1	0
405	2	3	2	3	0	1	0	0	0	0	1	0
406	2	3	2	3	0	1	0	1	0	0	1	0
467	2	3	0	3	0	0	1	0	0	0	1	1
468	2	3	0	3	0	0	1	1	0	0	1	1
471	2	3	0	3	0	1	1	0	0	0	1	1
472	2	3	0	3	0	1	1	1	0	0	1	1
473	2	3	0	3	1	0	0	0	0	0	1	1
474	2	3	0	3	1	0	0	1	0	0	1	1
475	2	3	0	3	1	0	1	0	0	0	1	1
476	2	3	0	3	1	0	1	1	0	0	1	1
477	2	3	0	3	1	1	0	0	0	0	1	1
478	2	3	0	3	1	1	0	1	0	0	1	1
479	2	3	0	3	1	1	1	0	0	0	1	1
483	2	3	1	3	0	0	1	0	0	0	1	1
484	2	3	1	3	0	0	1	1	0	0	1	1
485	2	3	1	3	0	1	0	0	0	0	1	1
486	2	3	1	3	0	1	0	1	0	0	1	1
487	2	3	1	3	0	1	1	0	0	0	1	1
488	2	3	1	3	0	1	1	1	0	0	1	1
489	2	3	1	3	1	0	0	0	0	0	1	1
490	2	3	1	3	1	0	0	1	0	0	1	1
491	2	3	1	3	1	0	1	0	0	0	1	1
493	2	3	1	3	1	1	0	0	0	0	1	1
494	2	3	1	3	1	1	0	1	0	0	1	1

Table E.8

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Decision matrix for patients within rule 59

P. No.	HBPD	LBPD	Spo2	BP	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	ST EL
177	2	3	0	3	0	0	0	0	1	1	0	1
178	2	3	0	3	0	0	0	1	1	1	0	1
465	2	3	0	3	0	0	0	0	0	0	1	1
466	2	3	0	3	0	0	0	1	0	0	1	1
469	2	3	0	3	0	1	0	0	0	0	1	1
470	2	3	0	3	0	1	0	1	0	0	1	1
481	2	3	1	3	0	0	0	0	0	0	1	1
482	2	3	1	3	0	0	0	1	0	0	1	1

Table E.9

Decision matrix for patients within rule 122

P. No.	HBPD	LBPD	Spo2	BP	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	ST EL
76	0	0	0	0	1	0	1	1	0	0	0	0
79	0	0	0	0	1	1	1	0	0	0	0	0
80	0	0	0	0	1	1	1	1	0	0	0	0
91	0	0	1	0	1	0	1	0	0	0	0	0
92	0	0	1	0	1	0	1	1	0	0	0	0
94	0	0	1	0	1	1	0	1	0	0	0	0
95	0	0	1	0	1	1	1	0	0	0	0	0
96	0	0	1	0	1	1	1	1	0	0	0	0
104	0	0	2	0	0	1	1	1	0	0	0	0
106	0	0	2	0	1	0	0	1	0	0	0	0
107	0	0	2	0	1	0	1	0	0	0	0	0
108	0	0	2	0	1	0	1	1	0	0	0	0
109	0	0	2	0	1	1	0	0	0	0	0	0
110	0	0	2	0	1	1	0	1	0	0	0	0
224	0	0	0	0	1	1	1	1	1	1	0	1
236	0	0	1	0	1	0	1	1	1	1	0	1
239	0	0	1	0	1	1	1	0	1	1	0	1
240	0	0	1	0	1	1	1	1	1	1	0	1
251	0	0	2	0	1	0	1	0	1	1	0	1
252	0	0	2	0	1	0	1	1	1	1	0	1
254	0	0	2	0	1	1	0	1	1	1	0	1
255	0	0	2	0	1	1	1	0	1	1	0	1
256	0	0	2	0	1	1	1	1	1	1	0	1
363	0	0	0	0	1	0	1	0	0	0	1	0
364	0	0	0	0	1	0	1	1	0	0	1	0
367	0	0	0	0	1	1	1	0	0	0	1	0
368	0	0	0	0	1	1	1	1	0	0	1	0

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379	0	0	1	0	1	0	1	0	0	0	1	0
380	0	0	1	0	1	0	1	1	0	0	1	0
381	0	0	1	0	1	1	0	0	0	0	1	0
382	0	0	1	0	1	1	0	1	0	0	1	0
391	0	0	2	0	0	1	1	0	0	0	1	0
392	0	0	2	0	0	1	1	1	0	0	1	0
393	0	0	2	0	1	0	0	0	0	0	1	0
394	0	0	2	0	1	0	0	1	0	0	1	0
397	0	0	2	0	1	1	0	0	0	0	1	0
398	0	0	2	0	1	1	0	1	0	0	1	0

Table E.10

Decision matrix for patients within rule 123

P. No.	HBPD	LBPD	Spo2	BP	Chest Pain	SH. Breath.	Palip.	rest?	Peaks	QRS width	P-P	STEl.
67	0	0	0	0	0	0	1	0	0	0	0	0
68	0	0	0	0	0	0	1	1	0	0	0	0
69	0	0	0	0	0	1	0	0	0	0	0	0
70	0	0	0	0	0	1	0	1	0	0	0	0
71	0	0	0	0	0	1	1	0	0	0	0	0
72	0	0	0	0	0	1	1	1	0	0	0	0
73	0	0	0	0	1	0	0	0	0	0	0	0
74	0	0	0	0	1	0	0	1	0	0	0	0
75	0	0	0	0	1	0	1	0	0	0	0	0
77	0	0	0	0	1	1	0	0	0	0	0	0
78	0	0	0	0	1	1	0	1	0	0	0	0
81	0	0	1	0	0	0	0	0	0	0	0	0
82	0	0	1	0	0	0	0	1	0	0	0	0
83	0	0	1	0	0	0	1	0	0	0	0	0
84	0	0	1	0	0	0	1	1	0	0	0	0
85	0	0	1	0	0	1	0	0	0	0	0	0
86	0	0	1	0	0	1	0	1	0	0	0	0
87	0	0	1	0	0	1	1	1	0	0	0	0
88	0	0	1	0	0	1	1	1	0	0	0	0
89	0	0	1	0	1	0	0	0	0	0	0	0
90	0	0	1	0	1	0	0	1	0	0	0	0
93	0	0	1	0	1	1	0	0	0	0	0	0
97	0	0	2	0	0	0	0	0	0	0	0	0
98	0	0	2	0	0	0	0	1	0	0	0	0
99	0	0	2	0	0	0	1	0	0	0	0	0
100	0	0	2	0	0	0	1	1	0	0	0	0
101	0	0	2	0	0	1	0	0	0	0	0	0
102	0	0	2	0	0	1	0	1	0	0	0	0

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103	0	0	2	0	0	1	1	0	0	0	0	0
105	0	0	2	0	1	0	0	0	0	0	0	0
211	0	0	0	0	0	0	1	0	1	1	0	1
212	0	0	0	0	0	0	1	1	1	1	0	1
215	0	0	0	0	0	1	1	0	1	1	0	1
216	0	0	0	0	0	1	1	1	1	1	0	1
217	0	0	0	0	1	0	0	0	1	1	0	1
218	0	0	0	0	1	0	0	1	1	1	0	1
219	0	0	0	0	1	0	1	0	1	1	0	1
220	0	0	0	0	1	0	1	1	1	1	0	1
221	0	0	0	0	1	1	0	0	1	1	0	1
222	0	0	0	0	1	1	0	1	1	1	0	1
223	0	0	0	0	1	1	1	0	1	1	0	1
227	0	0	1	0	0	0	1	0	1	1	0	1
228	0	0	1	0	0	0	1	1	1	1	0	1
229	0	0	1	0	0	1	0	0	1	1	0	1
230	0	0	1	0	0	1	0	1	1	1	0	1
231	0	0	1	0	0	1	1	0	1	1	0	1
232	0	0	1	0	0	1	1	1	1	1	0	1
233	0	0	1	0	1	0	0	0	1	1	0	1
234	0	0	1	0	1	0	0	1	1	1	0	1
235	0	0	1	0	1	0	1	0	1	1	0	1
237	0	0	1	0	1	1	0	0	1	1	0	1
238	0	0	1	0	1	1	0	1	1	1	0	1
241	0	0	2	0	0	0	0	0	1	1	0	1
242	0	0	2	0	0	0	0	1	1	1	0	1
243	0	0	2	0	0	0	1	0	1	1	0	1
244	0	0	2	0	0	0	1	1	1	1	0	1
245	0	0	2	0	0	1	0	0	1	1	0	1
246	0	0	2	0	0	1	0	1	1	1	0	1
247	0	0	2	0	0	1	1	0	1	1	0	1
248	0	0	2	0	0	1	1	1	1	1	0	1
249	0	0	2	0	1	0	0	0	1	1	0	1
250	0	0	2	0	1	0	0	1	1	1	0	1
253	0	0	2	0	1	1	0	0	1	1	0	1
354	0	0	0	0	0	0	0	1	0	0	1	0
355	0	0	0	0	0	0	1	0	0	0	1	0
356	0	0	0	0	0	0	1	1	0	0	1	0
357	0	0	0	0	0	1	0	0	0	0	1	0
358	0	0	0	0	0	1	0	1	0	0	1	0
359	0	0	0	0	0	1	1	0	0	0	1	0
360	0	0	0	0	0	1	1	1	0	0	1	0
361	0	0	0	0	1	0	0	0	0	0	1	0
362	0	0	0	0	1	0	0	1	0	0	1	0
365	0	0	0	0	1	1	0	0	0	0	1	0
366	0	0	0	0	1	1	0	1	0	0	1	0

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369	0	0	1	0	0	0	0	0	0	0	1	0
370	0	0	1	0	0	0	0	1	0	0	1	0
371	0	0	1	0	0	0	1	0	0	0	1	0
372	0	0	1	0	0	0	1	1	0	0	1	0
373	0	0	1	0	0	1	0	0	0	0	1	0
374	0	0	1	0	0	1	0	1	0	0	1	0
375	0	0	1	0	0	1	1	0	0	0	1	0
376	0	0	1	0	0	1	1	1	0	0	1	0
377	0	0	1	0	1	0	0	0	0	0	1	0
378	0	0	1	0	1	0	0	1	0	0	1	0
385	0	0	2	0	0	0	0	0	0	0	1	0
386	0	0	2	0	0	0	0	1	0	0	1	0
387	0	0	2	0	0	0	1	0	0	0	1	0
388	0	0	2	0	0	0	1	1	0	0	1	0
389	0	0	2	0	0	1	0	0	0	0	1	0
390	0	0	2	0	0	1	0	1	0	0	1	0

Table E.11

Decision matrix for patients within rule 124

P. No.	*HBPD*	*LBPD*	*Spo2*	*BP*	*Chest Pain*	*SH. Breath*	*Palip.*	*rest?*	*Peaks*	*QRS width*	*P-P*	*ST El.*
65	0	0	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	1	0	0	0	0
209	0	0	0	0	0	0	0	0	1	1	0	1
210	0	0	0	0	0	0	0	1	1	1	0	1
213	0	0	0	0	0	1	0	0	1	1	0	1
214	0	0	0	0	0	1	0	1	1	1	0	1
225	0	0	1	0	0	0	0	0	1	1	0	1
226	0	0	1	0	0	0	0	1	1	1	0	1
353	0	0	0	0	0	0	0	0	0	0	1	0
497	0	0	0	0	0	0	0	0	0	0	1	1
498	0	0	0	0	0	0	0	1	0	0	1	1
499	0	0	0	0	0	0	1	0	0	0	1	1
500	0	0	0	0	0	0	1	1	0	0	1	1

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Appendix (F)

Table F.1

Patient prioritisation within rule 2

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 8	0.021	43	Patient 276	0.059	11
Patient 10	0.012	60	Patient 279	0.060	8
Patient 11	0.012	58	Patient 280	0.066	2
Patient 12	0.019	49	Patient 281	0.051	18
Patient 13	0.013	57	Patient 282	0.058	13
Patient 14	0.020	46	Patient 285	0.059	12
Patient 20	0.016	54	Patient 286	0.065	3
Patient 23	0.017	52	Patient 295	0.026	36
Patient 24	0.024	39	Patient 296	0.032	28
Patient 25	0.008	62	Patient 297	0.017	53
Patient 26	0.015	56	Patient 298	0.023	41
Patient 29	0.016	55	Patient 301	0.025	37
Patient 30	0.022	42	Patient 302	0.031	29
Patient 131	0.012	59	Patient 307	0.021	44
Patient 132	0.019	50	Patient 308	0.027	33
Patient 134	0.019	48	Patient 311	0.028	32
Patient 135	0.020	45	Patient 312	0.035	27
Patient 136	0.026	34	Patient 313	0.020	47
Patient 137	0.011	61	Patient 314	0.026	35
Patient 138	0.017	51	Patient 419	0.024	40
Patient 155	0.052	17	Patient 420	0.030	31
Patient 156	0.059	10	Patient 421	0.024	38
Patient 158	0.060	9	Patient 422	0.031	30
Patient 159	0.060	7	Patient 444	0.041	25
Patient 160	0.067	1	Patient 447	0.042	24
Patient 168	0.064	4	Patient 448	0.048	20
Patient 170	0.055	16	Patient 459	0.037	26
Patient 171	0.055	15	Patient 460	0.043	23
Patient 172	0.062	6	Patient 462	0.044	22
Patient 173	0.056	14	Patient 463	0.044	21
Patient 174	0.062	5	Patient 464	0.051	19

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Table F.2
patient prioritisation within rule 3

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 1	0.000	74	Patient 275	0.044	12
Patient 2	0.008	70	Patient 277	0.041	16
Patient 3	0.011	67	Patient 278	0.049	4
Patient 4	0.019	53	Patient 289	0.007	71
Patient 5	0.008	69	Patient 290	0.015	59
Patient 6	0.016	57	Patient 291	0.018	55
Patient 7	0.019	51	Patient 292	0.026	41
Patient 9	0.016	56	Patient 293	0.016	58
Patient 17	0.003	73	Patient 294	0.023	44
Patient 18	0.011	66	Patient 305	0.011	68
Patient 19	0.014	63	Patient 306	0.019	54
Patient 21	0.012	65	Patient 309	0.019	52
Patient 22	0.020	50	Patient 310	0.027	40
Patient 129	0.007	72	Patient 417	0.014	64
Patient 130	0.015	62	Patient 418	0.022	48
Patient 133	0.015	61	Patient 435	0.023	47
Patient 145	0.026	43	Patient 436	0.031	36
Patient 146	0.034	31	Patient 437	0.020	49
Patient 147	0.037	25	Patient 438	0.028	39
Patient 148	0.045	10	Patient 439	0.031	35
Patient 149	0.034	30	Patient 440	0.039	22
Patient 150	0.042	15	Patient 441	0.028	38
Patient151	0.045	9	Patient 442	0.036	27
Patient 152	0.053	1	Patient 443	0.039	21
Patient 153	0.042	14	Patient 445	0.036	26
Patient 154	0.050	3	Patient 446	0.044	11
Patient 157	0.050	2	Patient 449	0.015	60
Patient 161	0.029	37	Patient 450	0.023	46
Patient 162	0.037	24	Patient 451	0.026	42
Patient 163	0.040	18	Patient 452	0.034	29
Patient 164	0.048	6	Patient 453	0.023	45
Patient 165	0.037	23	Patient 454	0.031	34
Patient 166	0.045	8	Patient 455	0.034	28
Patient 167	0.048	5	Patient 456	0.042	13
Patient 169	0.045	7	Patient 457	0.032	33
Patient 273	0.033	32	Patient 458	0.040	20
Patient 274	0.040	17	Patient 461	0.040	19

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Table F.3
patient prioritisation within rule 4

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 433	0.000	2	Patient 434	0.083	1

Table F.4
patient prioritisation within rule 56

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 63	0.005	19	Patient 347	0.007	17
Patient 64	0.012	10	Patient 348	0.013	8
Patient 123	0.002	20	Patient 351	0.010	12
Patient 124	0.009	15	Patient 352	0.017	4
Patient 127	0.006	18	Patient 411	0.007	16
Patient 128	0.012	9	Patient 412	0.014	7
Patient 271	0.072	2	Patient 413	0.010	13
Patient 272	0.078	1	Patient 414	0.016	5
Patient 335	0.009	14	Patient 415	0.011	11
Patient 336	0.016	6	Patient 416	0.017	3

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Table F.5
patient prioritisation within rule 121

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 111	0.021	7	Patient 395	0.021	8
Patient 112	0.065	3	Patient 396	0.065	4
Patient 383	0.038	6	Patient 399	0.039	5
Patient 384	0.082	2	Patient 400	0.083	1

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Table F.6
patient prioritisation within rule 57

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 43	0.009	51	Patient 264	0.069	2
Patient 44	0.015	45	Patient 266	0.059	12
Patient 46	0.016	43	Patient 267	0.058	13
Patient 47	0.016	44	Patient 268	0.064	5
Patient 48	0.022	31	Patient 269	0.059	11
Patient 56	0.022	34	Patient 270	0.066	4
Patient 58	0.011	49	Patient 331	0.021	36
Patient 59	0.011	50	Patient 332	0.027	26
Patient 60	0.017	40	Patient 333	0.022	33
Patient 61	0.012	48	Patient 334	0.028	24
Patient 62	0.018	38	Patient 343	0.027	25
Patient 116	0.016	42	Patient 344	0.033	20
Patient 119	0.017	39	Patient 345	0.017	41
Patient 120	0.024	29	Patient 346	0.023	30
Patient 121	0.007	52	Patient 349	0.024	28
Patient 122	0.013	47	Patient 350	0.030	21
Patient 125	0.014	46	Patient 403	0.022	32
Patient 126	0.021	35	Patient 404	0.028	23
Patient 188	0.060	10	Patient 407	0.029	22
Patient 191	0.061	9	Patient 408	0.035	19
Patient 192	0.067	3	Patient 409	0.019	37
Patient 203	0.056	14	Patient 410	0.025	27
Patient 204	0.062	8	Patient 480	0.047	16
Patient 206	0.064	6	Patient 492	0.042	18
Patient 207	0.063	7	Patient 495	0.043	17
Patient 208	0.070	1	Patient 496	0.049	15

Table F.7
patient prioritisation within rule 58

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 33	0.000	96	Patient 259	0.046	21
Patient 34	0.008	92	Patient 260	0.054	6
Patient 35	0.010	90	Patient 261	0.045	25
Patient 36	0.018	75	Patient 262	0.053	8
Patient 37	0.008	93	Patient 263	0.054	7
Patient 38	0.016	79	Patient 265	0.049	15
Patient 39	0.018	76	Patient 321	0.009	91
Patient 40	0.026	59	Patient 322	0.017	77

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Patient 41	0.013	85	Patient 323	0.018	74
Patient 42	0.021	67	Patient 324	0.026	57
Patient 45	0.021	68	Patient 325	0.017	78
Patient 49	0.004	95	Patient 326	0.025	60
Patient 50	0.012	88	Patient 327	0.026	58
Patient 51	0.013	86	Patient 328	0.034	45
Patient 52	0.021	69	Patient 329	0.021	65
Patient 53	0.012	89	Patient 330	0.030	51
Patient 54	0.020	73	Patient 337	0.012	87
Patient 55	0.021	70	Patient 338	0.020	71
Patient 57	0.016	80	Patient 339	0.021	66
Patient 113	0.007	94	Patient 340	0.029	52
Patient 114	0.015	84	Patient 341	0.020	72
Patient 115	0.016	81	Patient 342	0.028	53
Patient 117	0.015	83	Patient 401	0.015	82
Patient 118	0.023	64	Patient 402	0.023	62
Patient 179	0.039	34	Patient 405	0.023	63
Patient 180	0.047	16	Patient 406	0.031	49
Patient 181	0.038	37	Patient 467	0.024	61
Patient 182	0.046	19	Patient 468	0.032	47
Patient 183	0.047	17	Patient 471	0.032	48
Patient 184	0.056	3	Patient 472	0.040	32
Patient 185	0.043	28	Patient 473	0.028	54
Patient 186	0.051	10	Patient 474	0.036	40
Patient 187	0.052	9	Patient 475	0.037	38
Patient 189	0.051	11	Patient 476	0.045	22
Patient 190	0.059	1	Patient 477	0.036	41
Patient 193	0.033	46	Patient 478	0.044	26
Patient 194	0.041	30	Patient 479	0.045	24
Patient 195	0.043	29	Patient 483	0.027	55
Patient 196	0.051	12	Patient 484	0.036	42
Patient 197	0.041	31	Patient 485	0.026	56
Patient 198	0.049	14	Patient 486	0.034	44
Patient 199	0.051	13	Patient 487	0.036	43
Patient 200	0.059	2	Patient 488	0.044	27
Patient 201	0.046	20	Patient 489	0.031	50
Patient 202	0.054	4	Patient 490	0.039	35
Patient 205	0.054	5	Patient 491	0.040	33
Patient 257	0.037	39	Patient 493	0.039	36
Patient 258	0.045	23	Patient 494	0.047	18

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Table F.8
patient prioritisation within rule 59

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 177	0.035	2	Patient 469	0.021	5
Patient 178	0.044	1	Patient 470	0.030	3
Patient 465	0.004	8	Patient 481	0.021	6
Patient 466	0.013	7	Patient 482	0.030	4

Table F.9
patient prioritisation within rule 122

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 76	0.011	32	Patient 252	0.066	5
Patient 79	0.011	33	Patient 254	0.068	4
Patient 80	0.018	24	Patient 255	0.066	6
Patient 91	0.007	37	Patient 256	0.072	1
Patient 92	0.013	30	Patient 363	0.017	26
Patient 94	0.015	28	Patient 364	0.023	16
Patient 95	0.013	31	Patient 367	0.023	17
Patient 96	0.019	22	Patient 368	0.029	11
Patient 104	0.020	21	Patient 379	0.019	23
Patient 106	0.011	34	Patient 380	0.025	15
Patient 107	0.009	36	Patient 381	0.021	20
Patient 108	0.015	29	Patient 382	0.027	13
Patient 109	0.011	35	Patient 391	0.026	14
Patient 110	0.017	25	Patient 392	0.032	10
Patient 224	0.068	3	Patient 393	0.016	27
Patient 236	0.064	7	Patient 394	0.022	18
Patient 239	0.064	8	Patient 397	0.022	19
Patient 240	0.070	2	Patient 398	0.029	12
Patient 251	0.059	9			

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Table F.10

patient prioritisation within rule 123

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 67	0.009	87	Patient 231	0.050	17
Patient 68	0.016	76	Patient 232	0.057	5
Patient 69	0.008	88	Patient 233	0.044	26
Patient 70	0.015	77	Patient 234	0.052	14
Patient 71	0.017	74	Patient 235	0.053	10
Patient 72	0.024	55	Patient 237	0.052	12
Patient 73	0.011	84	Patient 238	0.060	2
Patient 74	0.019	71	Patient 241	0.036	36
Patient 75	0.020	67	Patient 242	0.043	28
Patient 77	0.019	69	Patient 243	0.045	25
Patient 78	0.026	50	Patient 244	0.052	13
Patient 81	0.003	90	Patient 245	0.044	27
Patient 82	0.010	86	Patient 246	0.051	15
Patient 83	0.011	83	Patient 247	0.052	11
Patient 84	0.019	70	Patient 248	0.060	1
Patient 85	0.010	85	Patient 249	0.047	23
Patient 86	0.018	72	Patient 250	0.055	9
Patient 87	0.027	48	Patient 253	0.055	7
Patient 88	0.027	49	Patient 354	0.020	68
Patient 89	0.014	80	Patient 355	0.021	64
Patient 90	0.021	63	Patient 356	0.029	46
Patient 93	0.022	61	Patient 357	0.020	66
Patient 97	0.005	89	Patient 358	0.028	47
Patient 98	0.013	82	Patient 359	0.029	45
Patient 99	0.014	79	Patient 360	0.036	35
Patient 100	0.022	62	Patient 361	0.023	57
Patient 101	0.013	81	Patient 362	0.031	43
Patient 102	0.021	65	Patient 365	0.031	41
Patient 103	0.022	60	Patient 366	0.039	34
Patient 105	0.016	75	Patient 369	0.015	78
Patient 211	0.039	32	Patient 370	0.022	59
Patient 212	0.047	24	Patient 371	0.024	56
Patient 215	0.047	22	Patient 372	0.031	42
Patient 216	0.055	8	Patient 373	0.023	58
Patient 217	0.042	30	Patient 374	0.030	44
Patient 218	0.049	20	Patient 375	0.031	40
Patient 219	0.051	16	Patient 376	0.039	33
Patient 220	0.058	4	Patient 377	0.026	52
Patient 221	0.050	18	Patient 378	0.034	38
Patient 222	0.057	6	Patient 385	0.017	73
Patient 223	0.058	3	Patient 386	0.025	54
Patient 227	0.042	29	Patient 387	0.026	51

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Patient 228	0.050	19	Patient 388	0.034	37
Patient 229	0.041	31	Patient 389	0.025	53
Patient 230	0.049	21	Patient 390	0.033	39

Table F.11

patient prioritisation within rule 124

Patient	*Score*	*Priority*	*Patient*	*Score*	*Priority*
Patient 65	0	13	Patient 226	0.041	2
Patient 66	0.007	12	Patient 353	0.009	11
Patient 209	0.016	9	Patient 497	0.011	10
Patient 210	0.024	7	Patient 498	0.018	8
Patient 213	0.034	4	Patient 499	0.028	6
Patient 214	0.041	1	Patient 500	0.035	3
Patient 225	0.034	5			

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