Standardisation and validation of a triage system in a private hospital group in the United Arab Emirates

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Declaration

I, **Enrico Dippenaar**, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Abstract

Introduction

Upon inspection and evaluation of the Mediclinic Middle East emergency centres in the United Arab Emirates, inconsistencies related to triage were found. Of note, it was found that the use of various international triage systems within and between the emergency centres may have caused potentially harmful patient conditions. The aim of this thesis was to study the reliability and validity of existing triage systems within Mediclinic Middle East, and then to use these systems as a starting point to design, standardise and validate a single, locally appropriate triage system. This single triage system should be able to accurately and safely assign triage priority to adults and children within all of Mediclinic Middle East emergency centres.

Methods

A System Development Life Cycle process intended for business and healthcare service improvement was expanded upon through an action research design. Quantitative and qualitative components were used in a five-part study that was conducted by pursuing the iterative activities set by an action research approach to establish the following: the emergency centre patient demographic and application of triage, the reliability and validity of the existing triage systems, a determination of the most appropriate triage system for use in this local environment and development of a best-fit novel triage system, establishment of validation criteria for the novel triage system, and determination of reliability and validity of the novel triage system within Mediclinic Middle East emergency centres.

Results

Low-acuity illness profiles predominated the patient demographic; high acuity cases were substantially smaller in number. The emergency centres used a combination of existing international triage systems; this was found to be inappropriate for this environment. Poor reliability and validity performance of the existing triage systems led to the development of a novel, four-level triage system. This novel triage system incorporates early warning scores through vital sign parameters, and clinical descriptors. The novel triage system proved to be substantially more reliable and valid than the existing triage systems within the Mediclinic Middle East emergency centres.

Conclusion

Through an initial systems analysis, it became clear that the Mediclinic Middle East emergency centres blindly implemented an array of international triage systems. Using an action research approach, a novel triage system that is both reliable and valid within this local environment was developed. The triage system is fit to be implemented throughout all the Mediclinic Middle East emergency centres and may be transposed to similar emergency centre settings elsewhere.

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List of Key abbreviations

For clarity and concision, only explanations of key abbreviations are included on this page. Full terms were used throughout this thesis with the exception of 'EC' that is explained on first use in each chapter. All other abbreviations were explained and expanded in text, tables, figures and boxes where necessary.

ACSCOT, American College of Surgeons Committee on Trauma

ANOVA, analysis of variance

CH, City hospital

CI, confidence interval

COREQ, consolidated criteria for reporting qualitative research

CS, Al Sufouh clinic

CTAS, Canadian Triage and Acuity Scale

EC, emergency centre

ESI, Emergency Severity Index

IB, Ibn Battuta clinic

IMRD, introduction, methods, results and discussion

MTS, Manchester Triage System

SALSA, search, appraisal, synthesis and analysis

SATS, South African Triage Scale

SDLC, Systems Development Life Cycle

STROBE, strengthening the reporting of observational studies in epidemiology

WH, Welcare hospital

List of Key terms

For clarity and concision, only explanations of key terms and how they relate in this thesis are included on this page.

Action research, an interactive inquiry process that balances problem solving with data-driven collaborative analysis

Acuity, the level or severity of an illness

Category, a class of acuity priority delineated by a triage system

Clinical descriptor, words or expressions used to describe a physiological condition or illness

Critical thinking, the objective analysis and evaluation of an issue in order to form a judgement

Early warning score, a system that allocates numerical values based on findings from physiological parameters (i.e. vital signs)

Novel, new and original concept not formerly known or used

Priority, something regarded as more important than another

Reference standard, a pre-determined base used to measure against

Reliability, consistently good in quality or performance

Standardisation, the imposition of standards or regulations throughout a system

Triage, the assignment of degrees of urgency/priority to wounds or illnesses to decide the order of treatment

Triage system, a set of principles, procedures, methods and standards to perform triage

Validity, the quality of being logically or factually sound

Vignette, a short written description (e.g. a patient presentation scenario)

Chapter 1

1 Introduction

Every three years, the overall healthcare standard and performance within public and private healthcare facilities in the United Arab Emirates is evaluated by the Joint Commission International's accreditation committee. Attaining this commission's accreditation does not only signify a distinguished healthcare standard but is also a requirement set by local health authorities. This committee also provides recommendations to help improve healthcare for the population. At the end of 2013, an accreditation panel evaluated Mediclinic Middle East, one of the private hospital groups within the United Arab Emirates. One of the findings was that triage within the emergency centres of this hospital group was not functioning properly. Due to the fragmented triage system, risks to patient safety and its relation to the illness severities (i.e. acuity) were identified. The accreditation panel was only able to observe that an issue existed and did not investigate the root of the problem, nor determined how to solve it. In this way, the onus was placed on Mediclinic Middle East to make an effort to solve the problems associated with the triage system. As a result, solving the triage system issue became a top business priority for the senior management. They were given until the next Joint Commission International accreditation in 2016, to identify, amend, and improve triage.

1.1 The United Arab Emirates

The United Arab Emirates is a country located in the southeast end of the Arabian Peninsula on the Persian Gulf. It has southern borders with Oman and Saudi Arabia and is across the Arabian Gulf from Qatar and Iran (Figure 1.1).(1–3) The United Arab Emirates was established on the 2nd of December 1971 whereby six Trucial Coast states, known as Sheikhdoms, combined as a constitutional federation.(1,3) A seventh Sheikhdom joined the United Arab Emirates in 1972 to form the present-day United Arab Emirates.(1,3) The Sheikhdoms, popularly referred to as Emirates, consist of: Abu Dhabi (capital), Dubai, Sharjah, Ajman, Umm AL Quwain, Fujairah, and Ras Al Khaimah.(1–4)

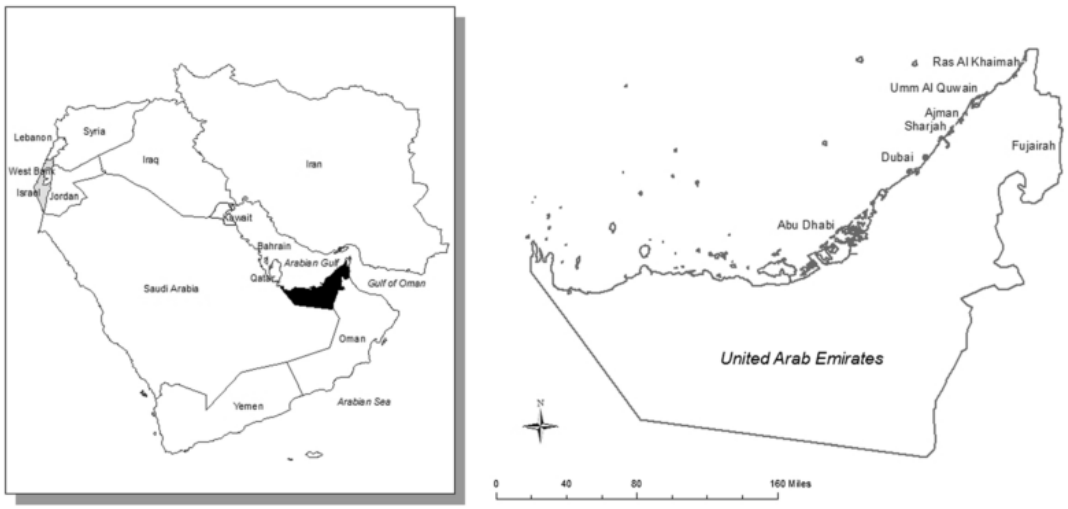


Figure 1.1 The location of the United Arab Emirates in the Middle East (from Fares et al. 2014)(2)

According to the World Health Organisation, the United Arab Emirates had a total population of 9.3 million in 2013.(5) The Emirate of Abu Dhabi, was most populous, having 2.7 million residents and the Emirate of Dubai, the second most populous, having 2.1 million residents.(6,7) Less than 20% of residents within the United Arab Emirates are nationals.(6) The largest expat population come from south Asian countries like India, Bangladesh, Pakistan, Sri Lanka, and include Iran and the Philippines. Western expats from Europe, Australia, North America, and also South Africa, are in the minority but have a growing presence in multi-cultural cities like Abu Dhabi and Dubai.(1,3,6,7) The United Arab Emirates has one of the highest population growth rates in the world at 9.2% and an average life expectancy of 76 years.(4–6) Regarding healthcare, the United Arab Emirates has a physician to population ratio of 19.3/10,000.(4,6) Abu Dhabi public hospitals alone report 14.3 million patient encounters per year.(6) The Dubai private healthcare sector receives an average of 350,000 emergency cases per year which is standard for the region.(6,7) The high non-communicable, chronic disease rates are mostly attributed to lifestyle; the top contributors being obesity, diabetes and cardiovascular disease.(6) Cardiovascular diseases alone accounted for 36.7% of all deaths in 2013.(6)

Healthcare within the United Arab Emirates is progressive. It has gained momentum in the last decade after the rapid economic and urban developments within Abu Dhabi and Dubai in the first decade of the new millennium. The establishment of healthcare regulatory bodies such as the Health Authority of Abu Dhabi, the Dubai Health Authority and the over-arching Ministry of Health for the entire United Arab Emirates have sought to westernise both the public and private healthcare sectors.(8–10) The growing private healthcare sector mainly caters for the expat population, and as per government regulations, all foreign residents have to be given healthcare insurance by their local employer.(10) Local healthcare regulations further determine that government emergency centres (ECs) are the primary facilities that receive major trauma.(10) These regulations are safety driven, a universal cornerstone within healthcare, however, they can be seen as very restrictive and controlling to those trained in western healthcare systems.(2) The prospect of new developments within a growing healthcare sector as unique as the United Arab Emirates, promises to be a fertile research environment.(8–10)

1.2 Triage systems within the United Arab Emirates

The triage systems currently used throughout the United Arab Emirates were adopted from various existing international systems, with the Canadian Triage and Acuity Scale being the most commonly used in government ECs.(11) Published information or research relating to triage systems used within the United Arab Emirates were lacking despite a literature search (Chapter 2). The search included reports and studies conducted within the United Arab Emirates in relation to the validity of international triage systems within its local environment, patient population or emergency requirements. Outcome measures and performance indicators in relation to triage have also not featured in the region, apart from some research conducted on the implementation of the Canadian Triage and Acuity Scale within Saudi Arabian public ECs.(12–14) With the resident population being predominantly expatriate, it is not surprising that the influence they have brought to the United Arab Emirates has included the triage systems being used today.(6)

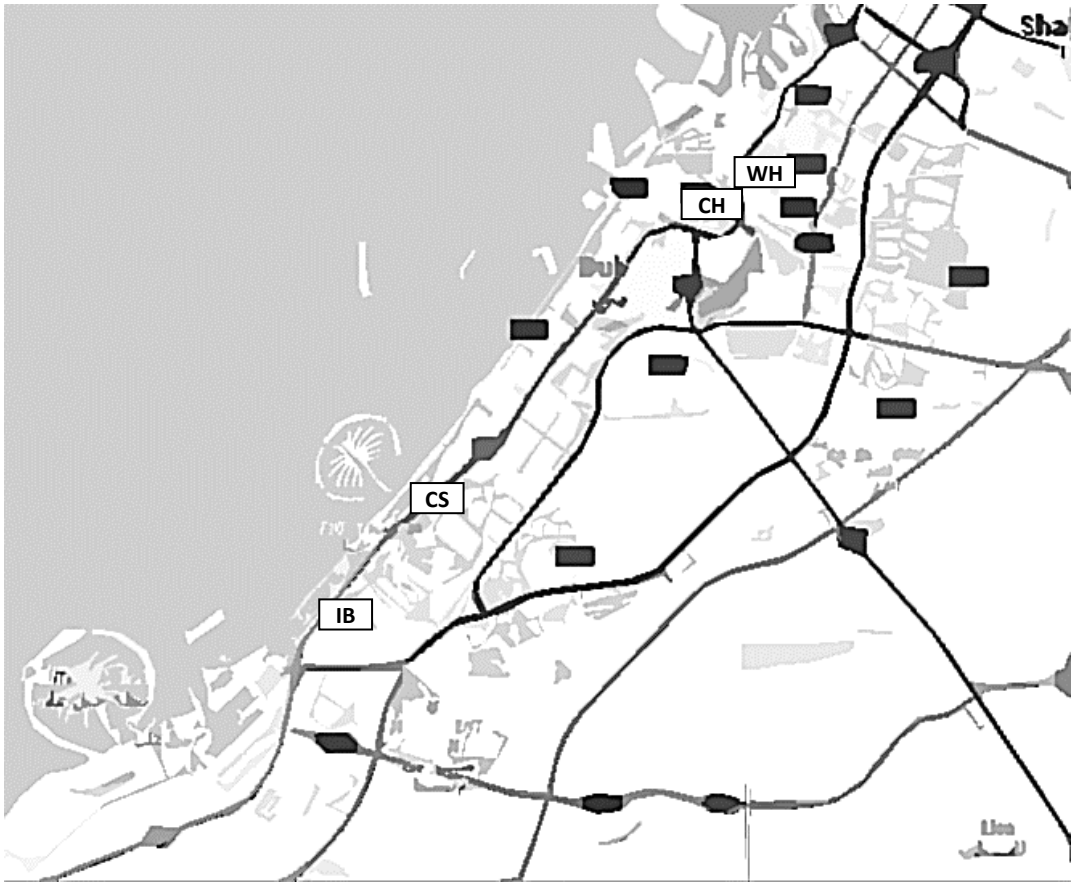
It is important to consider healthcare outcome measures with respect to the ethical environment in the Middle East. Medical norms and standards within the Middle East have mostly been adopted from western regions. However, limitations on practitioner scope of practice, especially those relating to nursing staff, can be restrictive in comparison.(8–11) Local law (i.e. Sharia Law) is different from western law in so far it is driven by religious conviction; this in turn regulates medical perceptions and outcome measures. As a simple example: all patients should undergo resuscitation before a declaration of death can be made; as a result a patient cannot be declared dead unless resuscitative attempts have taken place.(8–10) This is in contrast with western regions, where it is widely permissible under guidance for non-clinicians to declare a patient dead, either out of hospital or on arrival at the hospital, without resuscitative attempts.(8–10)

The capabilities of the public and private sector ECs are incongruous with regards too medical and trauma emergency care in accordance with Dubai Health Authority regulations. These regulations have restricted the capabilities of private healthcare providers by not allowing them to manage major trauma within their ECs.(8,11) Given the setting, it is important to understand whether international triage systems are valid within the United Arab Emirates private health sector, and if so, whether international triage outcome criteria are appropriate in relation to international validity and reliability measures.(11) With expected outcomes within the United Arab Emirates leaning strongly towards safety, the validity measures should also reflect a safe triage system, especially in cases of high acuity.(8,10,11,15–19)

1.3 Mediclinic Middle East

Mediclinic Middle East was established in October 2012 and is part of Mediclinic International, one of the top ten listed private hospital groups in the world.(11) It has 52 healthcare facilities in Southern Africa, 14 in Switzerland and ten in the United Arab Emirates. Mediclinic Middle East as a private healthcare organisation prides itself on high quality healthcare with “expertise you can trust”.(20) This has made Mediclinic an exclusive healthcare provider attracting a wide range of clients within

Dubai. Mediclinic Middle East has affirmed its quality of care by attaining Joint Commission International accreditation for all of its facilities in Dubai in 2013.(11) Currently, Mediclinic Middle East owns and operates two hospitals and eight clinics within the Emirate of Dubai with four of the ten facilities having an EC unit; two hospitals and two clinics (Figure 1.2).(11,20) The two hospitals with ECs are Welcare hospital in Al Garhoud, and City hospital in Dubai Healthcare City.(11,20) The two clinics with ECs are Al Sufouh clinic in Knowledge Village and Ibn Battuta clinic at Ibn Battuta mall.(11,20) Combined, these ECs service approximately 250 – 350 patients daily.(11) With an estimated Dubai population of 2.1 million in 2013, this equates to between 4.3% and 6.1% of the population seen in Mediclinic Middle East ECs each year.(7,11)



WH, Welcare hospital; CH, City hospital; CS, Al Sufouh clinic; IB, Ibn Battuta clinic

Figure 1.2 Map of Dubai with location of four emergency centres
Source: https://www.google.com/maps (21)

1.4 Triage within Mediclinic Middle East

Patients are allocated a triage category based on their acuity priority as derived from a specific triage system used within each respective EC.(11) Of note is that different triage systems or a combination of triage systems are used within and between the four ECs.(11) It is common for patients to be transferred from one facility to another based on resource requirements, notably where further intervention is required that is beyond the scope of the smaller clinics (i.e. Al Sufouh clinic and Ibn Battuta clinic).(11) Patients are also transferred between the two hospitals (i.e. Welcare hospital and City hospital) as these facilities share specialities; the two hospitals act as an extension of each other, with specialised care split between the two.(11) Irrespective of the emergency, all patients transferred from the clinics' ECs go through a reassessment within the receiving hospital's EC.(11) Patients are re-triaged on referral at the receiving hospital, using the receiving hospital's triage system. Given the variety of existing triage systems, the system used at the receiving hospital often differs from the transferring EC's system. This likely brings about inconsistencies and confusion with regards to patient acuity, that could result in misinterpretation and subsequent treatment delays as the Joint Commission International pointed out.(11)

As mentioned, each of the four Mediclinic Middle East ECs makes use of different, international triage systems.(11) These include the Canadian Triage and Acuity Scale, the Manchester Triage System, the Emergency Severity Index and the South African Triage Scale.(11) The onus rests on the ability of the triaging nurses to allocate a triage category based on the interpretation of one or, in some cases two triage systems.(11) Where nurses work between several of the ECs they are required to adapt to the respective existing triage system at each.(11) This increases the likelihood of error, having nurses use two different triage systems at the same time or alternate between systems. Using triage systems with different priority outputs further confounds the risk of error and resource allocation.(15,17,22) This, as pointed out by the Joint Commission International, opens the whole system to error and potentially harmful practice due to the variability of how triage systems are applied.

Mediclinic Middle East employs nursing staff from Asia, Europe, India and South Africa. Given the availability of regional triage systems, this means that nurses were most likely educated and trained differently with regards to EC triage.(11) As a result, staff knowledge and experience differ in the use and application of the locally used triage systems. Due to resource limitations, the clinical education department which is responsible for all internal training, has centralised triage training within Mediclinic Middle East by offering a one day, triage course. The course provides continued medical education and is accredited by the Dubai Health Authority.(11) The course covers the basic general elements of triage and then continues to focus on the Canadian Triage and Acuity Scale. However, it has been noted by EC nurse managers that when staff returned to their respective EC facilities, confusion arose when confronted with a triage system which was not included during training. This raised a concern for the potential for patient harm as confusion at the front door of the EC could set a patient on a course for delayed treatment.(11)

Although harm caused through triage has not been measured within Mediclinic Middle East ECs, the Joint Commission International accreditation process in 2013 highlighted the potential for harm due to the lack of triage system consistency throughout the ECs.(11) The differences in outcome measures, coupled with a lack of understanding and experience in the use of one standardised triage system, is likely to negatively impact patients. In trying to uphold Mediclinic Middle East's priority of providing a high level of safe and quality care the Joint Commission International found that the current usage of triage systems throughout Mediclinic Middle East's ECs is counter-intuitive, unproductive and likely harmful.(20)

1.5 A universal triage system for Mediclinic Middle East

The Joint Commission International accreditation in 2013 highlighted the fragmentation of triage systems throughout the four Mediclinic Middle East ECs.(11) Mediclinic Middle East senior management acknowledged that improved continuity of policies, procedures and medical care, including triage, between its various facilities were vital to Mediclinic Middle East operations within the United Arab

Emirates.(11) Mediclinic Middle East management further acknowledged the need for a universal, standardised and simplified triage system for all its ECs, and that this was to be based on local patient population characteristics.(11) Currently, there is no evaluation, test or review applied to validate the triage systems used locally, which likely also restricts any intended quality control measures.(11) Standardisation and simplification of one triage system will allow for better healthcare service delivery, more appropriate triage category allocations, improved quality control, reliability and uniform validation.(11,23–27)

Universal application of an already established international triage system may fit the requirements of Mediclinic Middle East's ECs and the patient demographic they serve. Evaluating the reliability and validity of currently used international triage systems within Mediclinic Middle East ECs can determine to what extent these systems function locally. However, it may be necessary to develop and design an alternative triage system that better suits the specific needs of the Mediclinic Middle East emergency care system, its patient population and the legal framework that underlines healthcare in the United Arab Emirates.

1.6 Aim

This thesis aims to study the reliability and validity of existing triage systems within Mediclinic Middle East ECs, and then to use these triage systems as a starting point to design, standardise and validate a single, locally appropriate triage system. This single triage system should be able to accurately and safely assign triage priority to adults and children within all of Mediclinic Middle East ECs.

1.7 Objectives

1. To describe, compare and correlate the triage allocations at the four Mediclinic Middle East ECs in terms of demographics, case load and principal diagnosis.

2. To describe the reliability and validity of the existing triage systems used within and between all four Mediclinic Middle East ECs, utilising a bespoke reference standard.

3. To determine the most appropriate validation criteria for a local triage system in order to derive the first version of a locally appropriate triage system for Mediclinic Middle East EC, using action research.

4. To describe, compare and correlate the triage allocations at the four Mediclinic Middle East ECs in terms of demographics, case load, principal diagnosis, patient flow timeframes, clinical descriptors and version 1 triage category allocations of the novel triage system.

5. To determine whether version 2 of the novel Mediclinic Middle East triage system was reliable and valid compared to the reference standard, and the existing triage systems.

1.8 Summary of key findings

Mediclinic Middle East was alerted by the Joint Commission International that the application of various triage systems within their EC operations opened up risks to patient safety. This thesis shows that none of the triage systems in use at the start of the study were appropriate for use as a stand-alone system within the low acuity Mediclinic Middle East EC environment. Through the application of a systems development and action research process, a novel four-level triage system that incorporates early warning scores and clinical descriptors was created. This system was shown to be a better fit for the Mediclinic Middle East EC environment.

1.9 About the layout of this thesis

This thesis involved the completion of five separate yet inter-dependant research studies to address the project aim and objectives. The introduction and background to this project is presented in this chapter together with the project aim and objectives. A review of the literature is presented in chapter 2. An overview of the research methodologies and designs are presented in chapter 3. A comprehensive description of each study follows consecutively from chapters 4 through 8.A. Relationships between the separate studies are highlighted throughout with referencing back to the main objectives. There are two short chapters, 7.A and 8.A, and are used to relate the progress of the project within its action research design. The overall research conclusion with discussion, limitations and recommendations can be found in chapter 9. References and appendices are presented at the end of the thesis.

Chapter 2

2 Literature review

"A literature review is an objective, thorough summary and critical analysis of the relevant available research and non-research literature on the topic being studied."

Hart, 1998 (28)

The goal of a literature review is to bring the reader up-to-date with current literature on the topic of interest or a subject of investigation.(28) It can be informative, critical, or a synthesis of a particular topic.(29) It can be used to identify what is known or not known in a subject area, to highlight areas of controversy or debate, and help to formulate questions for further investigation.(29) There are many methods for writing reviews, however, selecting a specific style is dependent on the purpose or goal the review wants to achieve. Grant and Booth (2009) identified 14 examples of reviews commonly used within health domains.(30) They mapped each review method with their associated key attributes against a Search, Appraisal, Synthesis and Analysis (SALSA) framework whereby the various review methods could be compared against each other.(30) In many instances, review methods have very similar attributes, with only minor differences setting them apart from each other. From the 14 examples, there were four main over-arching review methods which could delineate the fundamental aspects of literature reviews as used within thesis writing (Table 2.1).

A traditional or narrative literature review method was selected for its versatility by covering a wide range of information and giving a broad overview of the subject. From the SALSA framework: "this method may or may not include comprehensive searching; may or may not include quality assessment; is typically narrative; and analysis may be chronological, conceptual, thematic, etc.".(30) The purpose of this review was to gather available information on the subject of triage and to present it in a semi-structured format to help broaden the knowledge-base of triage.

Table 2.1 Description summary of the four over-arching review methods (28–30)

Traditional or Narrative	Examination and summary of a wide body of literature with broad conclusions about the subject in question.
Systematic	Rigorous and well-defined approach to systematically search for, appraise and synthesise research evidence from literature in a specific subject area.
Meta-analysis	Statistically combine and analyse the results of quantitative studies to provide a more precise effect and understanding of the results.
Meta-synthesis	Non-statistical technique used to integrate, evaluate and interpret the findings of multiple qualitative studies, usually to identify common elements and themes.

2.1 Literature sources

Searching for information on a subject is usually one of the first steps undertaken during a review. Information can be extracted from a wide variety of literary mediums such as articles (i.e. informative or researched), journals, reports, presentations, websites and books.(28,29) There have been numerous databases created to satisfy the vast quantities of information that can be made available through this online format. Sifting for relevant information on a specific subject can be daunting when faced with the prospect of receiving such vast quantities of information bytes and piecing them together. With this narrative literature review, the aim was to enlighten the subject of triage to a level that can be deemed satisfactory by the researcher to aid in further research efforts.

The majority of information for this review was gathered from articles sourced via the internet, by accessing search engine databases through the University of Cape Town's online library.(31,32) During initial searches, it was found that ScienceDirect.com had the most full-text articles available for download.(31) Publication inclusions could be skewed towards Elsevier publications, however, most searches using the same main keywords and/or combinations (e.g. triage, systems,

tools, processes, nurses, decision making, validation, reliability, performance, vignettes, Middle East, United Arab Emirates, etc.) on different search engine databases provided similar results and thus for ease of access, ScienceDirect.com was chosen as the primary search engine database.(31) Google.com searches, reference sites, reference sections of papers and articles given by colleagues were also considered and included where it would add appropriate value to the review.(33) All articles were imported into Mendeley Desktop, a free online referencing program, to provide easy access and direct referencing.(34) Keeping with the purpose and method of this review, relevant information was gathered from appropriate sources. Although cognisance was taken of the strengths and weaknesses of researched information, systematically evaluating these influences was not initially considered. Where articles were lacking the required information for the researchers' review, the aid of books and online websites were sought to fill in the missing pieces. In some instances, it was necessary to get information from relevant persons via email communication to ensure the most accurate information was presented.(11) All of the information used in this thesis is referenced using the Vancouver technique.

2.2 Review structure

Using a basic mind-mapping technique for information gathering, the *Five-W, One-H* questions (i.e. who? what? when? where? why? and how?) was used to gather a framework of information around triage (Figure 2.1).(35,36) The structure of these questions were not set in a specific sequence, nor was each question compulsory when applied to a heading of interest. This format of enquiry was merely used as a guide to help structure the review. As the elements of the mind-map were applied, the various questions that arose from it were answered. There was a basic list of questions formulated under each heading and presented for investigation and unpacking. The questions were answered in a manner which allowed for a story-like experience to understand triage. Although these questions only touch on the broad aspects of each heading, more comprehensive discussions are made in the text.

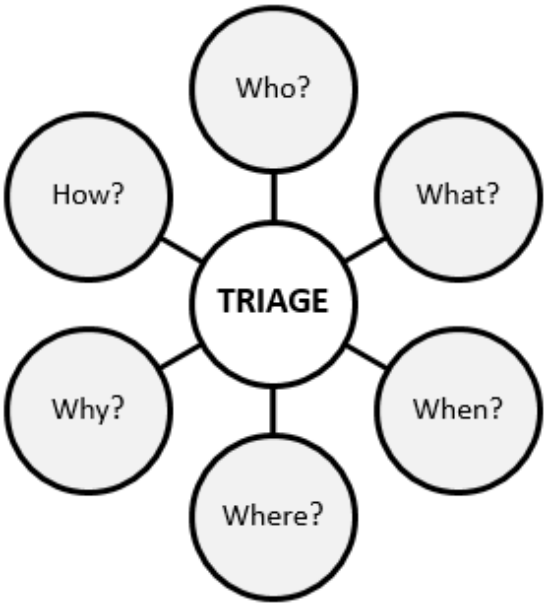


Figure 2.1 Five-W, One-H mind-map questions for triage (35,36)

2.3 History of triage

What is triage? Who and when was it discovered or invented? Where is it applied? Why and how is it used?

The Oxford English dictionary defines "triage" as: *noun* – "(in medical use) the assignment of degrees of urgency to wounds or illnesses to decide the order of treatment of a large number of patients or casualties"; *verb* – "decide the order of treatment of (patients or casualties)".(37) In relation to triage, "acuity'' is defined as: "the level or severity of an illness".(38)

Various sources further expand on the working definition, aims and objectives of triage; the most poignant are summarised below (Box 2.1). In essence, these can be summarised using the following three terms which essentially captures a simplified understanding of triage:

- **Identification** through clinical assessment
- **Classification** of acuity from injury or illness
- **Prioritisation** of appropriate treatment and medical care

Box 2.1 Literature abstractions on the definition of triage

- "The aim of triage assessment is to quickly determine and classify the patients in the order of urgency based on the need for treatment."(39)
- "Triage is the process of sorting patients according to acuity."(23)
- "Triage is the preliminary clinical assessment process that sorts patients prior to full emergency centre diagnosis and treatment, so that in the setting of resource constraints, patients with the highest acuity are treated first."(40)
- "…it is important to treat patients according to need, instead of according to order of arrival."(41)
- "The necessity of categorising patients by severity to deliver the most efficient care is crucial in overcrowded emergency centres."(42)
- "An efficient triage system regulates the length of patients' waiting times in the emergency centre by combining immediate assessments and interventions."(43)

The history and development of emergency triage is best described in a literature review by Fry and Burr in 2002.(16) According to them, triage can be traced back to Baron Dominique Jean Larre, who in the 1840s prioritised the medical needs of military casualties by using a military triage system.(16) He applied the French word *trier* which is the origin of the English word *triage* during his process of sorting.(44,45) This triage concept was refined during subsequent wars and demonstrated that early triage assessment, prompt resuscitation and early patient transfer reduced mortality rates.(45) It eventually came to the attention of civilian health care providers who desired to reduce acute care mortality in the non-combat environment.(45) During the late 1970s and early 1980s emergency centres began to develop, implement and review their own triage systems.(16) Medical staff constructed contextually based aims and expectations to improve patient flow and safety through innovative triage coding systems using numbers, colours, ribbons, balloons or the alphabet to indicate patient urgency.(45) These triage systems have led to better treatment decision-making timeframes and thus improved patient morbidity and mortality.(45,46)

In the early days of EC triage, it was performed by a variety of acute care personnel with varying degrees of experience and education.(47–50) The United States of America was the first to assign the responsibility of triaging EC patients to nurses back in the 1970s and as a result formalised emergency triage which became a sub-speciality of emergency nursing.(47,51,52) By the 1980s Britain had assigned a dedicated triage nurse to most of its ECs.(49) Australia implemented the role in the late 1980s, but restricted the position to business hours with clerical staff performing the role after hours.(16) During this time, there were no national guidelines for allocating triage codes and nurses learnt the role by adopting their departments' norms and expectations.(53) There has since been a shift in focus, with medical and nursing research concentrating on triage practises, and in particular measuring patient outcomes whilst demonstrating the validity of triage guidelines.(16) Since Fry and Burr's publication in 2002, the development and validation of triage systems have been an important goal and focus for research in a variety of settings.(39,54)

2.4 International triage systems

What is a triage system? Who designs triage systems? Why are triage systems used? What are the most common triage systems? Where did these triage systems originate from? How do triage systems work and differ from each other?

Existing triage systems are based on consensus opinions from expert groups in the clinical emergency medicine field.(55) These expert groups design decision trees or algorithms to support clinical risk assessments and predictions based on research evidence and are used to define urgency/priority levels.(55) Modern EC triage was first developed in Australia, the United Kingdom, Canada and the United States of America.(43) Most current triage systems follow a categorically measured acuity scale consisting of three-, four- or five-levels depending on their requirements.(25) Although no universal standard for triage exists, various modern triage systems have evolved to include five-level acuity scales.(42,56–60) Most American hospitals used only three triage levels or categories in the past, whereas the five-level triage systems prevailed moreover in Canada, Australia and in the United Kingdom.(40)

Originally, the concept of three levels was used in warfare situations where casualties could be sorted into either immediate, urgent or non-urgent based on how long they could wait to be treated.(44) The introduction of triage within the civilian EC environment saw most triage systems expanding on the three basic levels by introducing new levels between immediate/urgent and urgent/non-urgent.(45) This was the basic principal of how four- and five-level triage systems came into existence. Civilian EC patient populations can be similar to in-the-field wartime patient populations; in that they also see major trauma. However, civilian EC patient populations also deal with non-traumatic conditions and medical illnesses on a more frequent basis than military populations, depending on the specific environment.(16,44,45) This led to the current belief that patient acuity and subsequently, the urgency by which these patients are attended to, are best suited by the modern, five-level triage systems.(56–59) This extended delineation of the original three-level system was purely based on the requirements of ECs to sort patients and to assign them specific resources.(56–59) However, which five-level triage system is very dependent on the patient population, environment and overall needs of the EC in managing its patients.(56–59)

Many modern triage systems include the use of vital sign parameters (e.g. level of consciousness, respiratory rate, heart rate, blood pressure, oxygen saturation, and body temperature) with defined cut-off levels to aid in the determination of an acuity level.(54) In recent years, South Africa has also provided substantial development by creating their own unique triage system. This South African system places high importance on these vital sign parameter values to determine a specific acuity level.(26,61–63) Clinical descriptors are words or expressions used to describe a physiological condition or illness and are also used by modern systems to help differentiate between acuity level.(56–59) These two methods are the most predominant techniques used in modern triage systems.(56–59) Each system has its own application and weighted distribution of these techniques which are then used to determine acuity.(56–59) A brief overview of triage system development across various international regions is discussed below (Table 2.2).

Table 2.2 Summary of triage systems by year and country

Year developed	Triage system	Country used
1990	Emergency Severity Index (ESI)	United States
1993/4	National Triage Scale (NTS)	Australia
1996	Manchester Triage System (MTS)	United Kingdom
1997	Canadian Triage and Acuity Scale (CTAS)	Canada
1998	Taiwan Triage System (TTS)	Taiwan
2000/1	Australasian Triage Scale (ATS)	Australasia
2003	Toowoomba Adult Triage Trauma Tool (TATTT)	Australasia
2004	Cape Triage Score (CTS)	South Africa
2005	Medical Emergency Triage and Treatment Systems (METTS)	Sweden
2005	South African Triage Scale (SATS)	South Africa
2006	Adaptive Triage (ADAPT)	Sweden
2007	Supplemented Triage and Rapid Treatment (START)	United States
2010	Japanese Triage and Acuity Scale (JTAS)	Japan

2.4.1 Australian triage summary: the National Triage Scale (NTS), Australasian Triage Scale (ATS) and Toowoomba Adult Triage Trauma Tool (TATTT)

Australia adopted a five-level triage system called the National Triage Scale with the aim of promoting a standardised approach to triage in Australian ECs between 1993 and 1994.(16,27,43,64) The National Triage Scale used clinical algorithms, rather than diagnoses, to aid urgency in decision-making.(16) This approach to triage was thought capable of allocating the same triage category each time to any patient presenting to any triage nurse, in any EC, at any time of the day, with a specific problem.(27) However, their concern regarding the applicability of the system in rural areas and unaccredited ECs was questioned.(16) A number of experimental studies, including a study by Doherty in 1996, suggested a lack of standardisation in

the application of the system.(27,64) Despite this, the National Triage Scale formed a benchmark on which other systems (e.g. the British and Canadian) were based.(43) The National Triage Scale was revised at the turn of the millennium to include patients' vital signs and clinical symptoms, and was subsequently renamed the Australasian Triage Scale, for both Australia and New Zealand.(43,54,64–66) To improve national consistency of triage education, the Triage Education Resource Book was introduced in 2002. It contained recommendations from the Australian Association of Emergency Nurses.(65) More recently, an algorithmic decision support tool called the Toowoomba Adult Triage Trauma Tool was developed to address the need for consistency in triage assessment and categorisation; these were found to be lacking when the Australasian Triage Scale was applied.(27,64,67) This supportive tool, although limited to trauma cases, provided a standardised assessment approach to aid in the triage decision process.(27,64,67)

2.4.2 European triage summary: the Manchester Triage System (MTS), Adaptive Triage (ADAPT), Medical Emergency Triage and Treatment Systems (METTS)

The Manchester Triage System, a five-level algorithmic scale consisting of 52 flowcharts, is used in many European hospitals.(41,43,54,68–70) It was introduced within United Kingdom ECs in 1996 by the Manchester Triage Group. It has since been an accepted standard of EC care in Great Britain, Holland and Portugal.(24,43,68) The Manchester Triage System determines urgency levels and links this with time-to-physician assessment in a descending order of priority.(71) The goal of this triage system was to standardise the process and duration of triage within the EC and to show the benefit of nurse triage within the EC when based on consensus opinion.(72) In Sweden, three different triage methods are used: Adaptive Triage; Medical Emergency Triage and Treatment Systems; and the Manchester Triage System.(19,43,66,71) The Medical Emergency Triage and Treatment Systems was developed at Sahlgrenska University hospital, Gothenburg, and has been used in Swedish ECs since 2005.(19) The Medical Emergency Triage and Treatment Systems and later on Adaptive Triage, are based on subjective parameters combined with vital parameters also called emergency signs and symptoms.(66,71,73)

2.4.3 North American triage summary: the Canadian Triage and Acuity Scale (CTAS), Emergency Severity Index (ESI) and Supplemented Triage and Rapid Treatment (START)

Even though triage had been practiced there for decades, there was no nationally accepted triage system in Canada until the 1990s.(43,66,74) The Canadian Triage and Acuity Scale, a five-level triage system, was introduced in 1997.(17,74–76) Based on the National Triage Scale and Australasian Triage Scale systems, the Canadian model also adopted the use of vital sign parameters.(16,24,43,66,77) In addition, the Canadian Triage and Acuity Scale classifies patients in descending order of acuity which has emerged to be a more sensitive, accurate and reliable technique for safe, rapid patient assessment.(17,75–78) Currently, the hospitals in the United States of America use a variety of triage systems; the most widely used and dispersed triage system being the Emergency Severity Index, which has been in existence since the end of the 1990s.(24,42,43,66) This five-level triage system was designed and validated in the EC setting using a variety of patient presentations.(25,70,71,79,80) The Emergency Severity Index categorises patients, taking into considering both priority and resources, in order to rapidly assess of patients.(71,79) The Supplemented Triage and Rapid Treatment clinical care program, was designed and introduced in 2007 to assist with EC throughput as overcrowding in ECs has become a national crisis in the States.(81) However, its effect has not been measurably established.(81) The Supplemented Triage and Rapid Treatment program complements standard EC triage with a team of clinicians who initiate the diagnostic process and selectively accelerate a subset of patients.(81)

2.4.4 Asian triage summary: the Japanese Triage and Acuity Scale (JTAS) and Taiwan Triage System (TTS)

In 2010, the Japanese Society for Emergency Medicine, in conjunction with other Japanese medical societies, developed the Japanese Triage and Acuity Scale.(78) Based on the Canadian Triage and Acuity Scale, the Japanese Triage and Acuity Scale was the first standardised triage system in Japan with the expectation that it would function similarly to the Canadian Triage and Acuity Scale in Canada.(78) The reason

for choosing the Canadian Triage and Acuity Scale as the model was due to its demonstrated excellent inter-rater reliability.(78) After implementation of the Japanese Triage and Acuity Scale, it was found that inter-rater agreement and reliability improved to similar levels as the Canadian triage and Acuity Scale.(78) In Taiwan, the Department of Health and National Health Insurance has been promoting the use of the Taiwan Triage System since 1998.(15,17) The Taiwan Triage System is a four-level triage system based on concise criteria for major presentations or conditions.(15,17) Various studies comparing the Taiwan Triage System to the Canadian Triage and Acuity Scale and Emergency Severity Index have been conducted.(15,17) These studies however, highlight the various shortcomings and limitations of the Taiwan Triage System to accurately determine patient acuity and resource utilisation.(15,17)

2.4.5 African triage summary: the Cape Triage Score (CTS) and South African Triage Scale (SATS)

The Cape Triage Score was introduced in 2004 in Cape Town, South Africa, and subsequently renamed the South African Triage Scale after national roll-out by the developers of the system.(26,43,62) The South African Triage Scale was developed "out of a need for an accurate measure of urgency based on physiological parameters and clinical discriminators that is easily adopted in low resource settings."(63) The South African Triage Scale assigns triage with decreasing priority, using physiological parameters (i.e. vital signs) and clinical presentations within a two-staged approach.(61) Physiological parameters are evaluated using the Triage early warning score, an adapted version of the modified early warning score.(61,63) This adaptation was required after the un-adapted modified early warning score was found to be unsuitable as a unified triage scoring system for both medical and trauma cases within the South African EC context.(61,63) The South African Triage Scale was the first of its kind to delineate such prominent focus on vital sign parameters. It resulted in a system that could be used by entry-level healthcare providers.(61,63)

2.4.6 Paediatric triage summary: the Paediatric Canadian Triage and Acuity Scale and Child and Infant South African Triage Scale

It is important to realise that paediatric patients' physiological and clinical presentations may differ widely within different paediatric age ranges and from those of adult patients.(69,82–88) Most triage systems focus on the evaluation of acuity based on adult findings, however specific paediatric indicators have been developed in conjunction with well-known triage systems that incorporate physiology as part of the assessment.(69,82–88) Various triage systems such as the Paediatric Canadian Triage and Acuity Scale and the Child and Infant South African Triage Scale, have been developed to address the gap between adult and paediatric triage.(63,82,84) The Manchester Triage System, with its 52 flowcharts, was designed with 49 of the charts applicable to paediatrics.(69,86)

2.5 Reliability and validity of triage systems

Who or what determines an appropriate triage system? Why do we need to evaluate a triage systems performance? What are the considerations during triage system evaluation? When are such evaluations conducted? How do we evaluate triage systems?

With so many triage systems to choose from, reliability and validity become important considerations in determining which system is best for a specific EC environment.(23–27,40) As a result, these parameters tend to be widely reported on in the literature, albeit and in a number of ways, when triage scale validation is considered. Triage mandates consistency and accuracy, irrespective of whether used by one or many triage nurses, in one or many settings.(64) Evaluation can be challenging as most study methods struggle to adequately replicate the complexity of the entire triage process.(42) The definitions of reliability and validity in triage differ from their typical use in epidemiology which may cause confusion when not properly clarified.(26) Existing studies show that reliability and validity are closely linked, which highlights the importance of considering both during the evaluation of a triage system.(23–27,40)

2.5.1 Reliability

The Oxford English dictionary defines reliability as: *adjective* – "consistently good in quality or performance; able to be trusted"; *noun* – "a reliable person or thing".(89) This definition is further expanded in the literature with relation to triage (Box 2.2).

Box 2.2 Literature abstractions on the definition of reliability

- "The reliability of a triage scale is a measure that tells us how standardised the application of a triage scale is."(26)
- "…it refers to agreement between raters and within raters, using the scale, without reference to the patient's true acuity."(62)
- "Reliability refers to the degree of intra-observer variability and inter-observer variability."(55)
- "If the triage model is reliable, the end result of the triage will be the same."(24)

The definitions suggest that the reliability of a triage system addresses mainly the **consistency** of its performance (i.e. coming up with the same answer). In simple terms, this means that the identification, classification and prioritisation of patients should be the same for each case presentation, irrespective of who conducts the triaging.

2.5.2 Measure of reliability

In statistical terms, when measuring reliability, the focus is on the precision of the measure to produce similar results under consistent conditions.(23–25,90–93) To evaluate the reliability of a triage system however, two variables, namely EC conditions and raters, need to be evaluated for consistency. Firstly, reproducing consistent conditions within an EC is near impossible and secondly, rater dynamics vary considerably based on the individual's background, training, experience and understanding of the triage system.(43,65,77) Assessing these two variables will

determine the reliability strength of a triage system by its ability to produce similar results under inconsistent conditions and between different raters.(23–25,90–93)

Because there is an almost unlimited number of possible patient presentations to an EC the conditions under which a triage system is applied cannot be consistently replicated.(56–59) It is however known that patients with similar conditions can be grouped together (i.e. cardiac, respiratory, abdominal, etc.) and will commonly have similar or consistent presentations (i.e. signs and symptoms).(56–59) The number of raters is usually confined to a group that is measurable. When raters apply a triage system, the outcome is the allocation of a triage category that reflects the patient's priority. The relationship measured between raters is commonly referred to as inter-rater reliability/agreement. Thus, the degree of agreement is measured between two or more raters to determine how they relate to an outcome (i.e. triage category allocation).(23–26,90,93,94)

The measure of reliability within most triage studies focuses on the level of inter-rater agreement.(95–97) There are several methods to measure and evaluate inter-rater agreement, including joint probability of agreement, kappa statistics, correlation coefficients, limits of agreement and Krippendorff's alpha.(98–102) Joint probability of agreement is simply the number of times a rating is assigned by a rater divided by the total number of ratings.(98–102) Kappa statistics goes further by taking into account the amount of agreement that could be expected through chance.(98–102) Correlation coefficients evaluate the agreement or relationship between groups of raters.(98–102) Limits of agreement uses paired rater means to determine how much random variation may influence individual ratings.(98–102) Krippendorff's alpha is used to assess the agreement among raters who allocate measurable values to unstructured phenomena to determine whether the data can be trusted.(98–102) The most commonly used measures of reliability in triage is that of chance-corrected Cohen's kappa and inter-class correlation coefficients.(23–26,90,93,94) Since it is widely used within triage research this helps to cross-compare studies and evaluate any new findings made.

Cohen's kappa considers both percentage agreement and the percentage of agreement expected by chance.(98–104) This is the original and simplest form and is referred to as unweighted kappa where a nominal coefficient is used to measure the agreement between raters when sorting criteria of equal strength or value. (100,101,105–107) Cohen's kappa is however limited to two raters at a time, while the adapted Fleiss' kappa designed on the same principle can be used for any fixed number of raters. Unweighted kappa is further confounded in that it can only be applied to criteria of similar strength and does not take into account the degree of disagreement between raters.(100,101,103–107)

Weighted kappa was introduced to allow for the criteria to be allocated values in an ordinal manner so that the degree of agreement or disagreement can be measured.(100,101,103–107) This allows for certain criteria to be given a higher precedence when the magnitude of agreement or disagreement is calculated. (100,101,103–107) The two methods of allocating these weights can be either linear or quadratic.(100,101,103–107) In linear weighting, the degree of weight or precedence allocated to a predetermined rating is reduced by the same amount in a stepwise manner, whereas by quadratic weighting, the amount of weight or precedence that is reduced escalates the more you move away from the predetermined rating (Table 2.3).(92,93,99–101,105,106,108) The determination of weights to certain criteria allows for equal assessment of variation between agreement and disagreement between the raters.(100,101,103–107) This is useful when the disagreement between two raters is a more serious consequence for some situations than others. For example, it would be a more serious consequence for two raters to disagree on the allocation of a high acuity triage category than a low acuity triage category. The swift management of high acuity and possibly life-threatening cases thus depend greatly on the agreement between raters, where low acuity cases can afford more disagreement between the raters as the cases are not, by definition, life-threatening. Adding these arbitrary weights has however been criticised for creating potential bias through arbitrary weight allocations and the subsequent establishment of inflated inter-rater agreement.(103,104,109)

Table 2.3 Examples of linear and quadratic weighted Cohen's kappa (107)

Linear weighted scale example					
	A	**B**	**C**	**D**	**Weighted Scale**
A	1.00	0.67	0.33	0.00	1.00
B	0.67	1.00	0.67	0.33	0.67
C	0.33	0.67	1.00	0.67	0.33
D	0.00	0.33	0.67	1.00	0.00
Quadratic weighted scale example					
	A	**B**	**C**	**D**	**Weighted Scale**
A	1.00	0.89	0.56	0.00	1.00
B	0.89	1.00	0.89	0.56	0.89
C	0.56	0.89	1.00	0.89	0.56
D	0.00	0.56	0.89	1.00	0.00

The following is a practical example of kappa weight allocation. The conditions are: agreement is calculated based on triage priority, where high priority is given a value of two and low priority a value of one, when the kappa agreement is calculated between two raters, the chance-correction will be in favour of the high priority and will receive a higher kappa agreement than if it was unweighted. This means that emphasis is placed on agreement between higher priority triage allocations rather than agreement between lower priority triage allocations. By further allocating weights to the importance of disagreements, it is possible to determine not only the agreement levels but also the variation of disagreement.(92,93,99–101,105,106,108) For example, if there were three priorities (e.g. high, moderate and low), the disagreement variation between high and low is larger than between high and moderate or moderate and low. The larger the variation of disagreement the more unreliable the triage system becomes. A triage system with strong agreement and minimal variation among raters on a triage category is deemed to be reliable.

When kappa is applied it is important to interpret the results in an appropriate way.(92,99,105) Reference levels have been arbitrarily chosen to reflect the agreement calculated through kappa.(91,99,101,107) These levels provide a guide for determining the relative sense of agreement and are useful when comparing the agreement between various studies on the same subject.(91,95,99,101,105,107,108) The most popular reference level of kappa was presented by Landis and Kock in 1977, although others have since been proposed by Altman (1991) and Fleiss (2003) (Table 2.4).(91,99,101,107) These levels merely serve as a guide and should not be interpreted as absolutes; it is advocated to combine the kappa results with other outcomes when interpreting inter-rater agreement.(91,95,99,101,105,107,108) Reported findings where kappa was applied to evaluate inter-rater reliability in triage systems is presented below (Table 2.5).

Table 2.4 Reference levels on strength of agreement measured by Cohen's kappa

Landis and Koch (1977)		**Altman (1991)**		**Fleiss (2003)**	
Cohen's Kappa	**Strength of agreement**	**Cohen's Kappa**	**Strength of agreement**	**Cohen's Kappa**	**Strength of agreement**
0.81 – 1.00	Excellent	0.81 – 1.00	Very good	0.75 – 1.00	Very good
0.61 – 0.80	Substantial	0.61 – 0.80	Good	0.41 – 0.75	Fair - good
0.41 – 0.60	Moderate	0.41 – 0.60	Moderate	< 0.40	Poor
0.21 – 0.40	Fair	0.21 – 0.40	Fair		
0.00 – 0.20	Slight	< 0.20	Poor		
< 0.00	Poor				

Table 2.5 Extract of reported kappa reliability findings of nine studies

Reference	**Triage System**	**Quadratically Weighted Kappa (95% CI)**	**Unweighted Kappa (95% CI)**
Wuerz et al. (40)	ESI	0.80 (0.76 – 0.84)	
Eitel et al. (110)	ESI	0.78 (0.74 – 0.83)	

Worster et al. (111)	ESI	0.91 (0.90 – 0.99)	
	CTAS	0.89 (0.88 – 0.99)	
Rutschmann et al. (42)	CTAS	0.41 (0.20 – 0.61)	
Dallaire et al. (74)	CTAS	0.44 (0.40 – 0.48)	
Beveridge et al. (23)	CTAS	0.80 (0.79 – 0.81)	
Olofsson et al. (24)	MTS	0.81 (0.78 – 0.88)	0.61 (0.57 – 0.65)
van der Wulp et al. (112)	MTS	0.62 (0.60 – 0.65)	0.48 (0.45 – 0.50)
Twomey et al. (26)	SATS	0.76 (0.67 – 0.84)	0.68 (0.62 – 0.74)

CI, confidence interval; ESI, Emergency Severity Index; CTAS, Canadian Triage and Acuity Scale; MTS, Manchester Triage System; SATS, South African Triage Scale

Correlation coefficients are quantitative measures used to determine the statistical relationship or association between two or more variables, data sets, groups, etc. (93,95,99,100,107,109,113) There are three main types of correlation coefficients, i.e. Pearson product-moment correlation, rank correlation and inter-class correlation.(93,95,99,100,107,109,113) Pearson product-moment measures the strength and direction of linear relationships; rank correlation measures the relationships between the rankings of different variables or different rankings of the same variable (e.g. Spearman's, Kandall tau, Goodman and Kruskal); inter-class is a descriptive statistic used to determine the relationship within groups and how individual units within groups resemble each other.(93,95,99,100,107,109,113)

Inter-class is the most common form of correlation used within triage research as it is able to quantify the degree to which individuals or groups with a fixed degree of relatedness (i.e. the triage rater(s)) resemble each other.(23,26,113) Inter-class correlation is also sometimes used as a measure of agreement between two groups of triage raters as these groups usually resemble each other (e.g. triage nurses) however, it is the association between the groups that is most important to establish true reliability.(96,104,108,109,113) Inter-rater reliability conversely has also been loosely interpreted as the correlation between selected measurements on a subject by raters or between groups of raters, and it has been proposed that quadratically weighted kappa can thus also be interpreted as an inter-class correlation. (96,104,108,109,113)

2.5.3 Validity

The Oxford English dictionary defines validity as: *noun* – "the quality of being logically or factually sound; soundness or cogency".(114) This definition is further expanded on in the literature with relation to triage (Box 2.3).

Box 2.3 Literature abstractions on the definition of validity

- "The validity of a triage scale is an important measure that tells us how close an acuity rating assigned using that scale is to the true acuity of that patient."(62)
- "Validity assesses whether the triage scale correctly identifies the true acuity of the patient."(26)
- "Validity refers to the degree to which the triage system predicts the true urgency."(55)
- "The validity corresponds to the model's sensitivity and specificity."(24)

The definitions suggest that the validity of a triage system addresses mainly the **accuracy** of its performance (i.e. coming up with the right answer). In simple terms, this means that with regards to triage, the identification, classification and prioritisation of patients should be correct and accurate in its prediction of acuity and urgency of treatment required.

2.5.4 Measure of validity

The validity of a triage system can be measured either subjectively or objectively. The subjective measures relate to the outcomes achieved based on the triage category allocation and is usually chosen arbitrarily to reflect the predictive accuracy of the triage system within a specific EC setting (Table 2.6).(15–19) These subjective reference standards can be picked purposefully based on the EC's needs, resources, economic gain or any other goal. In most cases, the reference standard chosen reflect a high level of safety and focus on patient outcomes. Since there is no ultimate right or wrong answer as to which reference standard to use, it becomes difficult to

compare the validity between triage systems when their outcomes are measured differently.(15–19)

Table 2.6 Common subjective reference standard used to evaluate the validity of triage systems (15–19,26,41,55,58,62,94,110,115)

Length of stay in hospital
Admission rate
Intensive Care Unit admission rate
Resource utilisation
Diagnostic resources
Mortality
Vital signs at presentation
Potentially life threatening conditions
Therapeutic interventions
Follow up
Expert panel

The objective measures relate to the accuracy of the triage system to be able to correctly assign a triage category to the correct patient priority. Performance indicators are the most common tools for measuring the objective validity of a triage system, i.e. sensitivity, specificity, over- and under-triage.(55,62,69,84,94,110,116) Sensitivity refers to the true positive rate where the proportion of positives are correctly identified, and specificity refers to the true negative rate where the proportion of negatives are correctly identified.(55,62,69,84,94,110,116) This means that the sensitivity measure is good at ruling out negative results and the specificity measure is good at ruling in positive results. A balance is needed between the sensitivity and specificity of a triage system to allow for accuracy but also provide a level of safety to include outlying variables. Over-triage is the measure of overestimating a patient's priority and allocating a higher triage category than required while under-triage is the measure of underestimating the patient's priority and allocating a lower triage category than required.(55,62,69,84,94,110,116)

To underestimate a patient's priority is of more concern as it may be detrimental to a patient to wait longer for treatment, especially for patients of high acuity. Overestimating a patient's priority is less concerning as it allows for a safety margin, although this may have negative impacts on the service delivery of an EC by depleting its resources unnecessarily.(55,62,69,84,94,110,116)

An acceptable balance of performance indicators is necessary for a triage system to be valid as they are inversely proportional to each other. In other words, when one goes up the other goes down. The benefit of measuring performance indicators is that studies on triage system performance can be compared against each other to determine whether one system is more valid than another for a specific environment. The limitation however, is similar to that of the subjective measures as there are no fixed or agreed upon standard levels of sensitivity, specificity, over-triage and under-triage.(55,62,69,84,94,110,116) It is difficult to compare the performance of a triage system as no gold-standard exists, and the standard also depends largely on what goals the EC wants to attain. The measure of performance is thus an internal process (i.e. internal validity) of evaluating the subjective and objective indicators to attain a desired outcome. In most cases, an external evaluation process (i.e. external validity) provides a better reflection of a triage system's performance as it can be compared to the performance of other triage systems throughout the world.(18,24,55,62,69, 77,80,117) Reported performance indicators show a wide range of findings by studies on the existing triage systems within Mediclinic Middle East ECs (i.e. the Canadian Triage and Acuity Scale, the Manchester Triage System, the Emergency Severity Index and the South African Triage Scale) (Table 2.7).(18,24,55,62,69,77,80, 117) It was noted from the literature that many studies used similar types of performance indicators to establish the accuracy of predicting hospital admission, a benchmark used for overall system performance.(18,24,55,62,69,77,80,117)

Table 2.7 Extract of reported sensitivity, specificity, over-triage and under-triage of eight studies*

Reference	Triage System		Sensitivity (95% CI)	Specificity (95% CI)	Over-triage	Under-triage
Stover-Baker et al. (18)	ESI		75.6% (71.3% – 79.5%)	84.5% (83.1% – 85.8%)		
Buschhorn et al. (80)	ESI	1	0%	97.3%		
		2	57.1%	84.9%		
		3	67.1%	68.1%		
		4	33.3%	93.1%		
Lee et al. (117)	CTAS	1	48.9% (38.5% – 59.5%)	96.3% (95.3% – 97.1%)		
		2	97.9% (92.5% – 99.7%)	89.2% (87.7% – 90.6%)		
Göransson et al. (77)	CTAS		75.2%		14.4%	10.4%
Van Veen et al. (69)	MTS	original	63% (59% – 66%)	79% (79% – 80%)	47%	15%
		modified	64% (60% – 68%)	87% (86% – 87%)		
Moll (55)	MTS	paediatric	63% (14% – 83%)	79% (45% – 96%)		
Olofsson et al. (24)	MTS	1				8%
		2			5%	4%
		3			11%	22%
		4			34%	3%
Twomey et al. (62)	SATS	1	78.3%	96.8%		21.7%
		2	80.9%	82.2%	5.8%	13.4%
		3	72.3%	89.0%	21.4%	6.3%
		4	68.1%	95.6%	31.9%	
		mean	75%	91%	15%	10%

* Figures presented as reported; CI, confidence interval; ESI, Emergency Severity Index; CTAS, Canadian Triage and Acuity Scale; MTS, Manchester Triage System; SATS, South African Triage Scale

2.6 Triage decision-making

What is decision-making? Why and how does decision-making relate to triage? Who does triage decision-making? Where and when are these decisions made?

Although the reliability and validity of certain triage systems in particular settings have been established, triage strategies and decision-making are complex processes that are not well understood.(79,118,119) In many developed countries, triage is frequently performed by registered nurses.(77,120) It follows that these nurses are also commonly the first people patients encounter when presenting to an EC.(77,120) The capability and consistency of a triage nurse's application of a triage system contributes greatly to its reliability and validity.(119) Furthermore, the triage decision-making process (Figure 2.2) is dependent on the knowledge and experience of the nurses gathering and evaluating the information required to make a triage decision.(43,65,121–123) It involves clinical judgements to be made within a relatively short time-frame.(121) As a result, the triage process aims to cope within these circumstances and requires critical thinking, rapid evaluation and decision-making.(60,124)

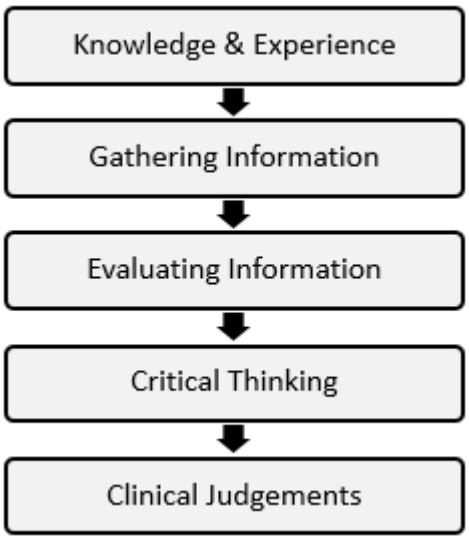


Figure 2.2 Triage decision-making process (43,65,121–123)

The Oxford English dictionary defines critical thinking as: *mass noun* – "the objective analysis and evaluation of an issue in order to form a judgement".(114) The question can then be asked: why is critical thinking a necessary part of triage when the purpose of a triage system is to consistently replicate a similar outcome using a formalised triage reference tool? Critical thinking therefore brings a level of subjectivity to the triage process which is counter acted by the objective purpose of a triage system.

To understand this surface contradiction, it should be understood that triage is a process with several steps that are intertwined within a triage system.(56–59) The majority of triage systems previously described have well known triage reference tools that are usually only a single page or in some cases a few pages long. These reference tools are used on a daily basis to help guide the triage process, however, they only highlight a small number of common patient presentations.(56–59) Like an iceberg floating in the ocean, the reference tool represents only the peak of a triage system. This is evident in the extensive triage manuals accompanying the triage systems which contain training information on all the aspects of the triage decision-making process.(56–59) The dynamics of the individual triage system also plays a large role in allowing for critical thinking to take place.(23,27,119,124) For example, some triage systems only provide a small reference tool with an emphasis on clinical judgement to reach a triage allocation while others have larger reference tools that need to be followed more stringently. The allowed scope of individuals performing triage is another factor to take into consideration.(125) For example, in some countries, individuals may be allowed a broad scope of independence and thus wide clinical judgement is allowed for, while in other countries, the limitations of practise (i.e. limited scope) deter clinical judgement from individuals conducting triage. There is no one scenario that is better than the other and thus cognisance of the needs of the setting ought to be taken when selecting a triage system.

The biggest confounders to clinical decision-making is the individual themself, including their background, training, experience and understanding of the triage system.(43,77,118,119,122–124,126) Appropriate triage training can aid in reducing the effects of this confounder. Including a solid understanding of triage theory and

its relationship to triage practice plays a vital role in the eventual quality of the outcome via the decision-making process.(77,121,123) It can be argued that better qualified individuals will need less training and refreshing than less qualified individuals, which saves resources in maintaining triage standards in the form of inter-rater reliability and validity.(79,120,121,126) Implementing a triage system to a specific setting from a decision-making standpoint is therefore dependant on the environment it will be used in, the individuals who will be using the system, the scope of clinical judgements that are allowed and the level of training that needs to be provided.

2.7 Current triage systems used by Mediclinic Middle East

What are the current triage systems used by Mediclinic Middle East? How are they different from each other? Why are they different from each other?

As previously described, it was understood that four triage systems were being used within Mediclinic Middle East's ECs.(11) All four of these are five-level triage systems, however, the South African Triage Scale is the only system that has an option for deceased within its final category.(57) This begs the question of whether the South African Triage Scale is truly a five-level triage system that can be compared to the other systems.(56–59) It is accepted that there are different triage systems for out of hospital as compared to in hospital practise and it is this variation that further sets the South African Triage Scale apart.(16,80,127–129) The Canadian Triage and Acuity Scale, the Manchester Triage System and the Emergency Severity Index have been designed, with all the other triage systems mentioned earlier in this chapter, for use predominantly within an EC environment.(56,58,59) The Emergency Severity Index has proved to perform poorly when used out of hospital however, the South African Triage Scale has been successfully designed to function as an extension of EC triage into the out of hospital environment.(57,80) The South African Triage Scale can thus be classified as a five-level triage system although its outputs are different from the other systems based on the environment is was designed to be used in.(57) The South African Triage Scale highlights the output variation among distinct triage

systems and why it is extremely difficult to compare triage systems designed for different settings. Besides the varying levels of triage systems, there are two main features that differentiate triage systems from one another; the first is structure (i.e. categories) and the second is content (i.e. clinical information).(56–59) The structural aspect is the framework of the triage system. Some of the common structural aspects include: the priority structure of the categories, the names and colour codes of the categories, and the time-to-physician (Table 2.8).(56–59) The content refers to the actual clinical information required to make a triage category allocation. Clinical information may include, but is not limited to: vital signs, level of consciousness, and presence of injury. It is of note, however, that the amount of clinical information displayed on a triage reference tool may be reduced to only contain common criteria. Thus, a more complete understanding of the system's clinical aspects is needed beyond that of the triage system's reference tool. The clinical differences are of prime importance and ultimately determines which triage category a patient is placed into.(56–59)

Table 2.8 Structural category differences of the four existing triage systems

Category	CTAS	MTS	ESI	SATS
1	Blue Resuscitation Immediate	Red Immediate Immediate	Level 1 Immediate	Red Emergency Immediate
2	Pink Emergent < 15 minutes	Orange Very urgent < 10 minutes	Level 2 High risk	Orange Very urgent < 10 minutes
3	Yellow Urgent < 30 minutes	Yellow Urgent < 60 minutes	Level 3 Many different resources	Yellow Urgent < 60 minutes
4	Green Less urgent < 60 minutes	Green Standard < 120 minutes	Level 4 One different resource	Green Routine < 240 Minutes
5	White Non-urgent < 120 minutes	Blue Non-urgent < 240 minutes	Level 5 No other resources	Blue Deceased

CTAS, Canadian Triage and Acuity Scale; MTS, Manchester Triage System; ESI, Emergency Severity Index; SATS, South African Triage Scale

2.8 Summary of the literature

Triage is a process by which the identification, classification and prioritisation of emergency cases are performed. It started in the 1840s and has developed considerably since then. Many international variations of this process were developed throughout the world to meet the needs of the specific environments in which triage systems are used. Mediclinic Middle East has adopted four international triage systems over the past years, however, patient safety has been a concern given that multiple triage systems are applied concurrently within and between ECs.

Reliability and validity are intertwined measures that are commonly applied to evaluate and determine the adequacy and performance of a triage system. These measures depend heavily on the decision-making capabilities of the individuals applying these systems. Within an ever changing environment, it is important to regularly evaluate the triage system and how it is used. Many methods exist and can be applied to confidently determine a triage system's reliability and validity within any environment. Furthermore, it is also important to apply the correct triage system to an appropriate environment and patient population.

Chapter 3

3 Methodology

At the outset, this project intended to integrate aspects of healthcare service improvement and research methodology to address the study aim through its objectives. A similar approach was taken as in the literature review by using the *Five-W*, *One-H* questions to guide this methodology to address the research aim.(35,36) This chapter will present an overview of the methodology by outlining the structure of the project. Each chapter that follows will present its own design as it pertains to that particular investigation, filling in the gaps of the structure outline as necessary. This overview will shed light on what was investigated, how it was investigated, who performed the investigation, as well as when and where these investigations took place.

This thesis aims to study the reliability and validity of existing triage systems within Mediclinic Middle East ECs, and then to use these triage systems as a starting point to design, standardise and validate a single, locally appropriate triage system. This single triage system should be able to accurately and safely assign triage priority to adults and children within all of Mediclinic Middle East ECs.

To address the project aim, a research design that could accommodate all the aspects of the aim was required. Such a design allowed for the quantification of numerical data that could then be used to statistically measure performance outcomes. Furthermore, an explorative design was also needed to gain an understanding about the encountered phenomena. In research terms, these concepts are defined as quantitative and qualitative research, respectively.(130–134) Each of these designs have various data collecting techniques capable of meeting the needs of the research. By acknowledging the complexity within the aim of this project, it was deemed reasonable to use a systematic approach with multiple layers of quantitative and qualitative designs. This mixed-component approach gave strength to the research investigation in that the data from both ends of the spectrum could be combined to complement each other to strengthen the evidence and results.(130–134)

3.1 Overview of research project

In viewing the project aim, it was necessary to unpack the aspects within it and to break it down into manageable pieces that could be investigated. These pieces translated to the objectives of the project and were used as a basis for conducting each study. It was first necessary to understand and get an overview of the patient demographics of Mediclinic Middle East's ECs through evaluating retrospective medical records. As described in the literature review, it is important to have a triage system that matches the needs of the patient population to which it will be applied. For triage purposes, it is valuable to know what type of injuries or illnesses present to the ECs, what level the acuity presentations are, what triage categories are most prevalent, and what the actual caseload volumes are within the ECs. After investigating the patient demographics, it was necessary to determine the reliability and validity of each of the existing triage systems used at the time. This was achieved by experimentally evaluating triage practice using vignettes with a predetermined triage category reference standard and thus establishing each system's performance. Following this, stakeholder meetings were held; the Mediclinic Middle East triage advisory committee evaluated the patient demographic data as well as the reliability and validity of each of the existing triage systems. It found that none of these were aptly suited for the local environment or population. Therefore, the committee determined that a novel triage system for Mediclinic Middle East ECs should be developed. Additional patient demographic and EC data were prospectively captured to provide relevant information that could be used to inform, develop and refine the novel triage system. These data were captured using a combination of electronic and manual medical records. A final evaluation of all the data resulted in the development of version 2 of the novel triage system. Version 2 of the novel triage system's performance was tested using an adjusted reference standard and the triage vignettes described earlier. A comparison of the performance indicators between the existing triage systems and version 2 of the novel triage systems was then made. This was done to establish whether version 2 of the novel triage system would be more valid and reliable within the Mediclinic Middle East EC environment than the existing triage systems.

3.2 Service improvement models

A key part of the methodology was deciding which service improvement model to use. Various models used in healthcare quality management and improvement were reviewed, including: Lean,(135–147) Six Sigma,(136–139,148–153) Plan-Do-Check-Act (154–159) and the Systems Development Life Cycle (160–169). All four of these systems originally came from some sort of engineering or business improvement perspective and have, over time, also been applied to the healthcare environment. These models have much in common, most notably being that they are used for improvement of a system or process; they offer and follow a task-based, stepwise guide; and they are continuing or cyclical by nature.

Although these models have much in common, there are subtle differences that renders one more desirable over another in specific applications. The Lean model, famously derived from the Toyota Motor Corporation, is a bundle of concepts designed to eliminate wasteful processes within manufacturing.(143,144) Essentially, the Lean model is used to assess what adds value to a process or system and what does not, and then what can then be removed to improve the system flow.(143,144) The Six Sigma model, introduced by an engineer working at Motorola, is very similar to the Lean model in that it identifies and removes the causes of defects within a system or process.(137,148,153) There is a clear focus by Six Sigma to achieve stable and predictable results by reducing variation.(137,148,153) The most commonly used healthcare improvement model is the Plan-Do-Check-Act model, also known as the Deming cycle.(154–159) The Plan-Do-Check-Act model is a simple four step approach with a focus on separating and completing each step individually before carrying on to the next step. It is a very simple method to follow in every day healthcare practise and allows for an easy means of continuous system or process improvement.(154–159) The application of these three models is mainly done within an already established system or process, with the goal to improve on what is already in existence.

The Systems Development Life Cycle (SDLC), commonly used for large scale business application where there is development of new, or the complete change of a system or process.(160–169) Believed to have originated through commercial business application of information systems in the 1960s, it became clear during that time that a more disciplined approach was required to the design and development of generalised systems.(165) This model allowed for a varied approach to complicated systems depending on the needs of the system or process by allowing for adaptations to be made, namely linear adaptation, iterative adaptation, combination adaptation or spiral adaptation.(162) Linear adaptation also known as waterfall, divides the project into directed sequential phases, with some overlap or backflow acceptable between phases. Iterative adaptation, also known as prototyping, reduces inherent project risk by breaking it down into smaller segments that will allow for ease-of-change during development. With this model, an initial investigation is followed by multiple design iterations before implementation and maintenance takes place. This adaptation further embraces stakeholder involvement and small scale system mock-ups throughout the project that will increase the likelihood of stakeholder acceptance. Combination adaptation, also known as incremental adaptation, combines linear and iterative adaptation by conducting mini-waterfalls before and after each iteration. Spiral adaptation, as the word suggests, is a continuous outward ellipse of the process from the start. Each cycle involves the same sequence of steps with outward elaboration creating layers of progress.(162)

Unlike the previous three healthcare improvement models that depend on a strict stepwise approach, the Systems Development Life Cycle in principal is flexible enough to allow for simultaneous action of various steps and the repetition of certain steps depending on the adaptation used. The main strength of this model lies in the control and management of large projects involving detailed parallel steps.(160–169) The Systems Development Life Cycle, which originated from commercial business, inherently lends itself towards business concepts such as targets, costs, active stakeholder involvement, high quality, reduced risk, documentation, and audits. Since Mediclinic Middle East is a private healthcare business, this model is likely to lend itself better to an institutional understanding of such a model. Ultimately, this

will contribute to the success of the project. It is likely that any of the other models could have been used to some degree as their foundational methodology is almost identical. The need for an initial investigation, a complete system change with the development of a novel triage system, and the post development implementation and maintenance, qualifies the Systems Development Life Cycle with an iterative adaptation as the most appropriate model given its strengths listed above.(162,166)

3.3 Systems Development Life Cycle applied to this thesis

The Systems Development Life Cycle uses a process of planning, analysis, design, implementation, and maintenance to attain the desired goal.(160–169) Planning requires a fair degree of knowledge regarding the process or system being evaluated and deals with the acquisition of information and resources for the project.(160–169) Analysis involves collecting and processing available data into meaningful bytes that can adequately inform the rest of the process.(160–169) Design simply refers to the process of development and the creation of an improved process within the system. (160–169) Implementation suggests the activation or execution of the designed process within the system's platform.(160–169) Maintenance requires that the system with the newly implemented process be continuously re-evaluated to determine optimal system performance.(160–169) The outcome of this project was to have a single, standardised triage system which was implementable within all Mediclinic Middle East ECs.

To achieve this goal, an iterative approach to the Systems Development Life Cycle was used (Figure 3.1).(160,162,164–166) Iterations are the repetition of processes where the previous results are applied to successively reach a solution or outcome. This thesis's focus is on the planning, analysis and design aspects of the Systems Development Life Cycle. These three steps can be repeated a multitude of times to a point where a satisfactory triage system is created for implementation. Although this will be the endpoint for this thesis, implementation and maintenance can be continued by Mediclinic Middle East for internal improvement purposes or even post-doc work.

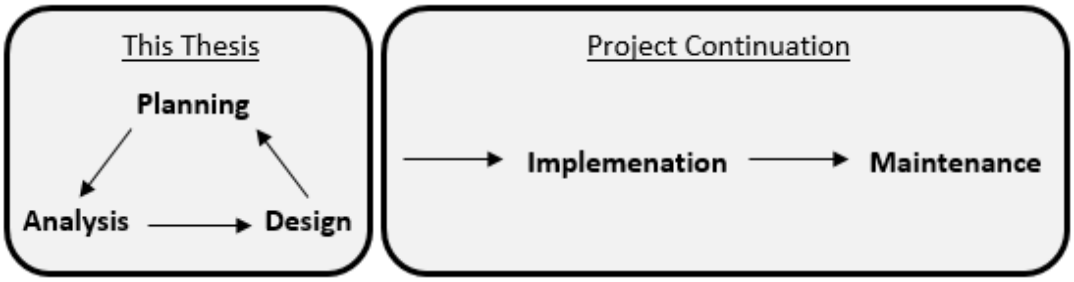


Figure 3.1 Iterative Systems Development Life Cycle applied to this thesis

3.4 Action research design applied to this thesis

The Systems Development Life Cycle is the over-arching methodological theory applied to this project. This thesis follows iterations of the planning, analysis and design steps to reach the goal of having a novel triage system that can be implemented within Mediclinic Middle East ECs. The iterative framework requires responsive actions to take place through stakeholder involvement. The stakeholder for this project is Mediclinic Middle East. With regard to this project, their participation in problem-solving and development was not only a prescribed requirement, but also fundamental to the success of the project. It was necessary to enact a design that would allow the researcher to facilitate a collaborative process whereby the stakeholder could be engaged in the research and become a problem-solver and developer. Therefore, an action research design was chosen to enact the iterative steps of the Systems Development Life Cycle.

Action research is well described in the literature as an interactive inquiry process that balances problem solving with data-driven collaborative analysis.(170–179) Action research focuses on methods and techniques of investigation that takes into account the sociological aspects within such investigations.(170) As the term suggests, it is a combination of action (i.e. to bring about change) and research (i.e. to increase understanding).(174) The history of action research is complex; it emerged as an approach to research over time from a broad range of fields.(171) The creation of the process is often attributed to Lewin (1946) who used the term in his

published works in the field of psychology.(170,173,178) Reference has also been traced to anthropological- and sociological-based community research by investigators such as Goodenough (1963), Mayo (1933), and Whyte (1943).(170) Its wide use in education may refer back to Buckingham's (1926) book, *Research for Teachers*, which advocates for a recognisable action research process.(178) Educational action research is a strategy used to develop teachers as researchers so that they may use their research to improve their teaching as well as their students' learning.(178) It is challenging to succinctly define and describe action research methodologically. It is seen as a natural process, a work in progress, that comes in many forms and has been developed for and used in a multitude of applications. These applications include administration, community development, organisational change, political change, agriculture, banking, health, technology and education amongst others.(171,178) There has been a range of methodological issues raised that are problematic for action researchers. Most notably is the nature of human action and the status and validity of the knowledge produced through action research.(173) It is believed by some researchers that having a theoretical rationale or methodology to their action research safeguards its claim to the status of real, legitimised research. An undebated discussion, however, still remains as to why it is necessary to define action research by reference to a methodology.(173) It is understood that a methodology cannot be derived from research itself but has to be grounded in a form of prior theoretical knowledge, usually referred to as philosophy.(173) In action research as in any other social science, the methodology stands in a particular relationship to philosophy such that research methods are justified by the former which are in turn justified by knowledge derived from the latter.(173) This trait has given action research the ability to be used across a wide spectrum of disciplines that use this as the base methodology and then elaborates on its design for that particular discipline's research needs.

Action research, like other conventional experimental research, had to develop its own set of principles to guide its conduct. These principals, described in more detail below, include being cyclical, participative, responsive, emergent, and reflective.(170–179) Action research is cyclical: an iterative process that traditionally involves

the steps of planning, action, observation and reflection (Figure 3.2).(170–179) For this thesis, these steps were amended to include planning, analysis and design, as previously discussed. Action research is participative: a democratic collaboration between stakeholders to solve goal oriented problems.(170–179) Action research is responsive: a process by which relevant action takes place throughout the process to affect change necessary for developmental progress.(170–179) Action research is emergent: a process that takes place gradually and aids in overall rigour by allowing progress within earlier cycles of the process to determine the development and outcomes for subsequent cycles.(170–179) During later cycles, the interpretations developed earlier can be tested, challenged and refined. Action research is reflective: a process of critical reflection and critique of what has already happened.(170–179) This process of reflection forms the knowledge and experience required to determine what developments and strategies were effective and what pitfalls should be attended to during the next cycle.(170–179)

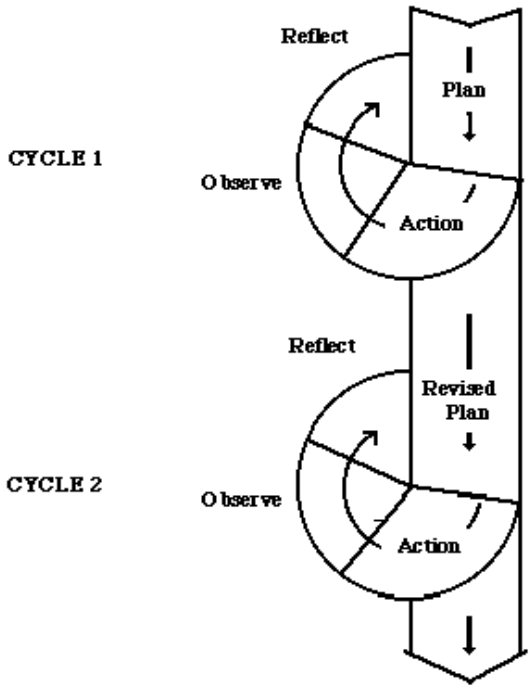


Figure 3.2 Cyclical nature of a typical action research process (from Young et al. 2010) (179)

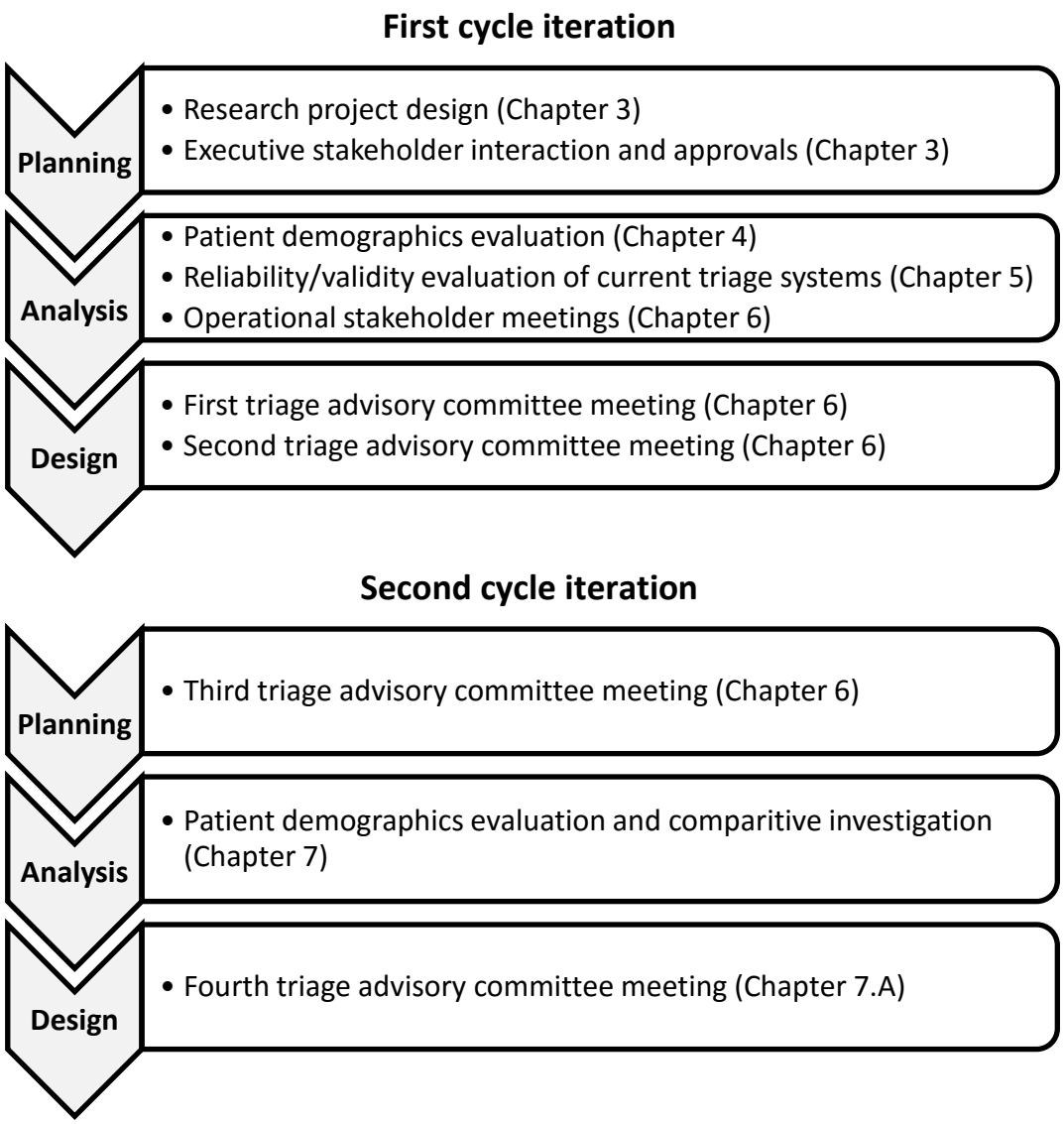
When approaching action research there are three main distinctive modes, namely technical, practical and emancipatory.(170,177,178) The technical mode is a traditional approach to action research; it tends to be conservative and maintains the status quo.(170,177,178) Its goal is to test a particular theoretical framework by facilitating an investigation through collaboration with a stakeholder.(170,177,178) For example, a researcher would identify potential problems within a hospital and collaborate with a hospital administrator through to implementing solutions. In this mode, the problem identification and solution development comes from the researcher and uses the stakeholder as a research medium.(170,177,178) The practical mode, however, is contextual and a more realistic, real-life approach to action research; it is a mutual collaboration between the researcher and the stakeholder.(170,177,178) Its goal is to identify problems and solutions together through mutual understanding, thus allowing the stakeholder to act as both a project designer and co-researcher.(170,177,178) For example, a researcher and a hospital administrator would identify potential problems within a hospital and develop solutions together. In this mode, the problem identification and solution development are achieved through mutual collaboration between the researcher and the stakeholder.(170,177,178) The emancipatory mode is a political approach to action research that promotes critical consciousness with the expressed aim of changing the status quo.(170,177,178) Its goal is to assist the stakeholder in unveiling clouded understandings to fundamental problems by raising collective consciousness.(170,177,178) For example, a researcher would assist a hospital administrator, who has already identified potential problems within a hospital and developed solutions, by facilitating an action. In this mode, the problem identification and solution development comes from the stakeholder and the researcher becomes the medium to affect change.(170,177,178) As previously discussed, this project required a mutual collaboration between the researcher and the stakeholder to plan, analyse and design a novel triage system for use in Mediclinic Middle East's ECs. With the varying modes of action research elucidated, a practical mode was decided upon and implemented.

3.5 Presentation of the methodology and design within this thesis

To contextualise the Systems Development Life Cycle methodology and action research design, the steps of the process were functionally implemented and represented as research phases during the course of data collection. These phases also represented the investigational studies that were conducted and are referred to as chapters in this thesis. Each phase represents a separate research investigation with its corresponding study design (Table 3.1). This project was divided into five studies. Each study follows the standard scientific reporting format: Introduction, Methods, Results and Discussion (IMRD).(180–182) To maintain continuity in health research reporting, the Equator Network was searched for appropriate reporting checklists to follow as a guide.(183) The Equator Network strives to improve the reporting quality of research and publications. Since there are many checklists that could fit a specific research paradigm, the decision in selecting a checklist falls arbitrarily to what the author believes best fits the research being reported. Chapters 4, 5, 7 and 8 follow the STROBE guidelines for reporting observational studies, while chapter 6, utilises the COREQ checklist for reporting the substantial parts of action research; action research is considered a qualitative research method.(184,185) Each study was addressed separately within their respective chapters, however, these chapters are inter-dependant and act as extensions from each other as part of the action research design. The studies were conducted as required to achieve a specific goal within either the planning, analysis of design steps of the action research design. Multiple studies could be required to address a single step; a single study could address one or more steps together or a complete iteration of the entire cycle. There were three iterations of the action research process in this thesis. The relationship amongst the chapters and their relevance to the action research process is discussed as the thesis progresses. It is also summarised in Figure 3.3. As previously stated, an overall conclusion (Chapter 9), at the end of the thesis provides the final arguments. The research proposal and primary stakeholder interaction resulted in research approval by establishing mutual collaboration between the researcher and Mediclinic Middle East. This addressed the first planning step by creating a framework from which the five studies were able to be built upon.

Table 3.1 Research investigations associated the phases, chapters and designs

Phase	Chapter	Design
1	4	Retrospective, cross-sectional evaluation of medical records
2	5	Prospective, cross-sectional investigation using triage vignettes
3	6	Interactive, semi-structured stakeholder meetings
4	7	Prospective, cross-sectional evaluation of medical records with a comparative investigation
5	8	Prospective, validation and reliability evaluation using triage vignettes



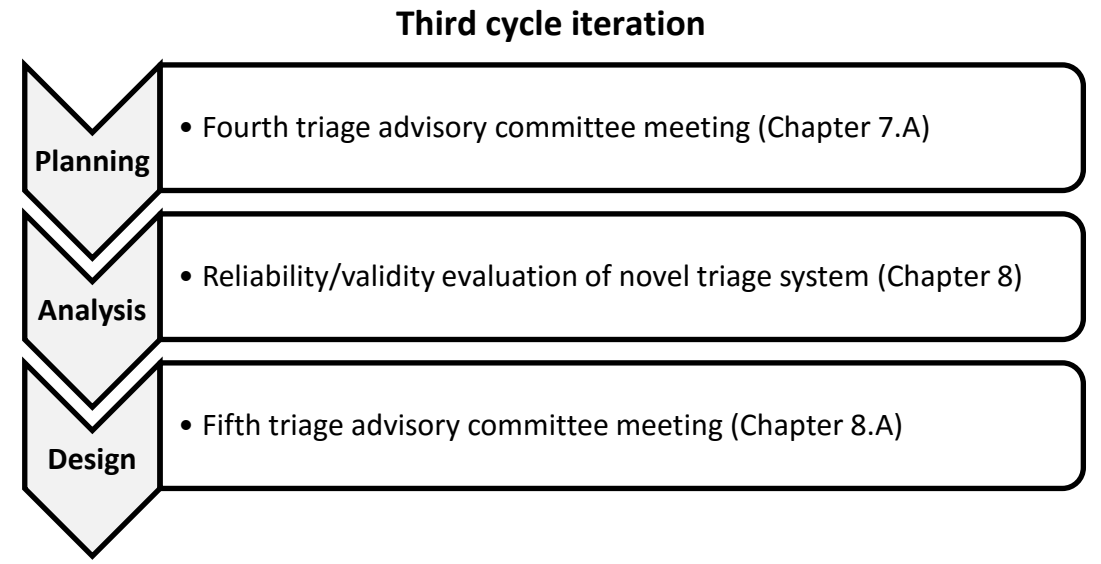


Figure 3.3 Chapter correlation and relevance in the action research process

3.6 Protocol deviations

It was accepted that the project protocol would serve as the study guideline but true to the nature of the PhD, some findings made during the initial phases of the study, that could not be predicted from the outset, required a rethink of the proposed protocol direction. This directional change is a reflection of the iterative action research approach taken by this project. As intended by this approach, the previous result, i.e. the initial findings, directly influenced the rest of the development process. This change positively affected the design of the project so that the aim was still successfully addressed. These deviations can be seen as the first cycle of planning, analysis and design resulted in these changes. During the course of the study, three minor deviations were made from the original protocol as new data and knowledge came to the forefront. These changes did not affect the aim, but rather the objectives.

Firstly, there was an intention to make a comparative analyses of vital parameter triage allocations using the South African Triage Scale in phase one. It became clear that the data required for this was severely lacking and thus it was removed. This comparative analysis was instead made in phase four of the project where data

collection could be controlled. Secondly, an initial objective to select and standardise one of the currently used triage systems within the ECs proved flawed. It became clear from data collected during phase three that none of the current systems in use would be locally appropriate, and thus a novel triage system had to be developed to fill this gap. This resulted in a swap over, and minor changes made, between the original phase four and phase five studies. Thirdly, with the creation of a novel system, and the complex dynamic associated with such an undertaking, it was decided to remove the implementation steps of the project. This was later determined by the research investigators to have no effect on the project objectives with the testing of the novel triage system occurring in phase five. As stated before, these protocol deviations did not affect the overall aim of the thesis. A protocol amendment was approved during an annual progress report by the University of Cape Town Human Research Ethics Committee under the same initial approval (HREC/REF: 744/2014).

3.7 Research setting, population and sample

This project was conducted within the four Mediclinic Middle East EC facilities, namely, Welcare hospital, City hospital, Al Sufouh clinic, and Ibn Battuta clinic. The population and samples used from these facilities are described in detail within the methods of each study chapter. In summary, chapters 4 and 7 sourced patient medical records, where chapters 5, 6 and 8 utilised staff from these facilities for its population. The population group is specific to Mediclinic Middle East ECs, so it was possible to use a purposive all-inclusive sampling method. All-inclusive sampling methods involve the choice of all readily available subjects to be actively chosen for the study, a common practice found in similar triage studies.(40,62,64,79,84,85,130) Purposive sampling methods refer to participants selected for a specific quality, such as allocation to triage duties. This allowed for the project to include the largest possible sample, potentially increasing the likelihood of relevant findings.(130) Similar to all the literature studies found on triage research, a confidence interval (CI) of 95% (i.e. significance level of 0.05) was chosen to determine the relationship of the findings to chance.

Confidence intervals describe the predictive variance of measurement error, thus the higher the confidence percentage, the less error anticipated around a given result.(97,113) In simple terms, if data is analysed across replicated study samples within the same population, the chances of reaching a similar result is described by the confidence interval bounds. Confidence intervals are also used to describe statistical precision and significance when unpowered samples are used, as was done in this project; low powered sample sets will simply reveal wide margins and high powered sample sets will reveal narrow margins.(97,113) This allows for confidence intervals to interpret precision, traditionally represented through p-values in an unpowered sample, where p-values are of questionable use.(97,113) The desired level of confidence is pre-set by the researcher, as was done in this project (at 95%), and thus the outcome levels are not determined by the data itself.(97,113) Exclusion criteria and subdivision into triage categories were the important factors that affected the sample sizes. Timeframes necessary for data collection, and thus population involvement, depended on the individual study conducted (Table 3.2).

Table 3.2 Research project data collection timeframes in relation to study phases

Phase	Chapter	Timeframe
1	4	November 2015 (retrospective July to August 2015)
2	5	26th April to 10th May 2015
3	6	1st May to 15th November 2015
4	7	1st to 31st August 2015
5	8	27th September to 25th October 2015

3.8 Data safety and monitoring

A detailed account of the data collecting methods is described in each of the study chapters. Where used, medical records were taken from the electronic hospital information system by the Mediclinic Middle East medical records department. A blinded approach was taken in chapter 4 by removing retrospective patient identifiable information before the raw data was transposed onto Microsoft Excel (©

Microsoft Office, Palo Alto, CA) spreadsheets and made available to the investigator.(186) Where manual medical records were captured, the data was transcribed onto a spreadsheet by Mediclinic Middle East clerical staff. In chapter 7, the researcher was responsible for merging electronic and manually captured data by combining the two spreadsheets and then removing any identifiers before analysis. The data captured in chapters 5 and 8 used the online questionnaire platform, SurveyMonkey (© SurveyMonkey, Palo Alto, CA), with access provided through the secure account of the University of Cape Town's Division of Emergency Medicine.(187) Unique, emailed links were automatically generated by the software and sent to the participants' official …@*mediclinic.ae* accounts. Initial participant identification was kept to ensure appropriate informed consent was sought from each participant before the raw data was extracted from the software onto spreadsheets. It was then anonymised prior to analysis. Observational notes were transcribed into a Microsoft Word (© Microsoft Office, Palo Alto, CA) document.(186) All data were kept secure on password protected, work-based computers, limiting access to the investigator and one of the project supervisors. All of these measures were done to ensure the anonymity and safety of each patient and staff participants.

3.9 Overview of the data analysis used within this thesis

The specific data analysis methods and statistical measures used by each study are further detailed within each chapter. An overview of the statistical methods used in triage research was described within the literature review and will be applied where necessary to meet the needs of each chapter. Statistics, in broad terms, is the study related to the collection, analysis, interpretation, presentation and organisation of data.(130,188–190) Statistical data can also be grouped into different data types, i.e. nominal, ordinal, interval and ratio (Table 3.3).(188,189,191,192) Descriptive statistics, as a specific type of statistics, were chosen as the over-arching method for analysing the data samples and with expected samples of entire population groups this seemed a reasonable fit. Descriptive statistics quantitatively describe and summarise the main features of a dataset, whereas inferential statistics (i.e. inductive statistics) deduce features from a smaller sample into a larger population.(188,193)

Central tendencies and dispersions are common measures used in descriptive statistics to effectively describe a dataset.(130,188,192) Central tendency measures the centre location of a dataset distribution and is expressed by the mean, median or mode (Table 3.4). Dispersion measures how wide or narrow the dataset distribution is, with variance as a type of dispersion measure that determines the expected random deviation of a dataset around its central location.(130,188,192)

Table 3.3 Statistical data types (188,189,191,192)

Data type	Description
Nominal	Data that follows a simple naming system to indicate commonality, e.g. list of countries
Ordinal	Data that follows a rank order by their position on a scale and thus indicate sequence, e.g. 1^{st}, 2^{nd}, 3^{rd}
Interval	Data that has an equal degree of difference between each position as measured along a scale, e.g. temperature
Ratio	Data that can be compared as multiples of one another to indicate magnitude, e.g. age and weight

Table 3.4 Measures of central tendency (188,189,191,192)

Central measure	Description
Mean	The sum of all the data points divided by the number of data points in the dataset, which is commonly also referred to as the average. Means are very susceptible to the influence of outlying data points which may distort the description of the dataset distribution, and is thus better suited when applied to a normal distribution.
Median	The middle value of a dataset where the data points are ranked from lowest too highest. Medians are less susceptible to the influence of outlying data points and provides a more accurate description of irregularly distributed datasets however, they mostly require ordinal data.
Mode	The most frequently occurring data point within a dataset. Modes provide poor descriptions of the dataset distributions and are the only measure that can be used with nominal data.

When analysing distributions, there are two common branches of statistics, parametric and non-parametric models. The main difference between these two statistical models is that of population and sample assumptions.(130,193–196) Parametric statistics assume that the data comes from a population that follows a probability distribution based on a fixed set of parameters, whereas non-parametric statistics are not bound to these predetermined assumptions.(130,193–196) These models each use different data types, relationships and central measures as the basis for their measures (Table 3.5).

Table 3.5 Description of parametric and non-parametric statistics (190,194–196)

Description	Parametric	Non-Parametric
Assumed distribution	Normal	Any
Assumed variance	Homogeneous	Any
Typical data types	Interval or Ratio	Nominal or Ordinal
Dataset relationships	Independent	Any
Usual central measure	Mean	Median

A common form of dispersion measurement used, and is elaborated on in chapters 4 and 7, is that of analysis of variance. Analysis of variance (ANOVA) is a collection of parametric statistical models that measure the variation among or between groups by comparing their means.(23,95,99,113,197) ANOVA permits the comparison of two or more means simultaneously by following a set of underlying assumptions.(130) ANOVA as a statistical technique has been extensively used in psychological research and consists of three models used to analyse variance: fixed-effects, random-effects, and mixed-effects. The fixed-effects model (class I) applies to situations where one or more actions are applied to subjects to see whether the response variable changes; the random-effects model (class II) applies when actions are not fixed as the response variable is random; the mixed-effects model (class III) is made up of a combination of the previous two models where the outcomes of the two are compared when used to evaluate a specific action.(23,95,99,113,197)

In general, ANOVA can be applied to triage research where the variance between different groups (e.g. shifts in the same EC, between ECs or countries) want to be measured. In some instances, the variance between the same group over time can be tested through test-retest, parallel-forms, or split-half methods. Test-retest directly assesses the consistency when the same test is applied two or more times, parallel-forms assesses the consistency when a similar test to the original is applied, split-half assesses the consistency when one half of the test scores are compared to the other half.(130) ANOVA can also be represented and explained using simple bell-curves (Figure 3.4). For example, curves A and B have similar distributions and their means are not far apart, but curve C has a different distribution and its mean is further apart from A; this means A and B have less mean variance than A and C. We can conclude that the relationship between A and B is stronger than the relationship between A and C; the mean variance result between group A and B is thus less random than the mean variance result between A and C.

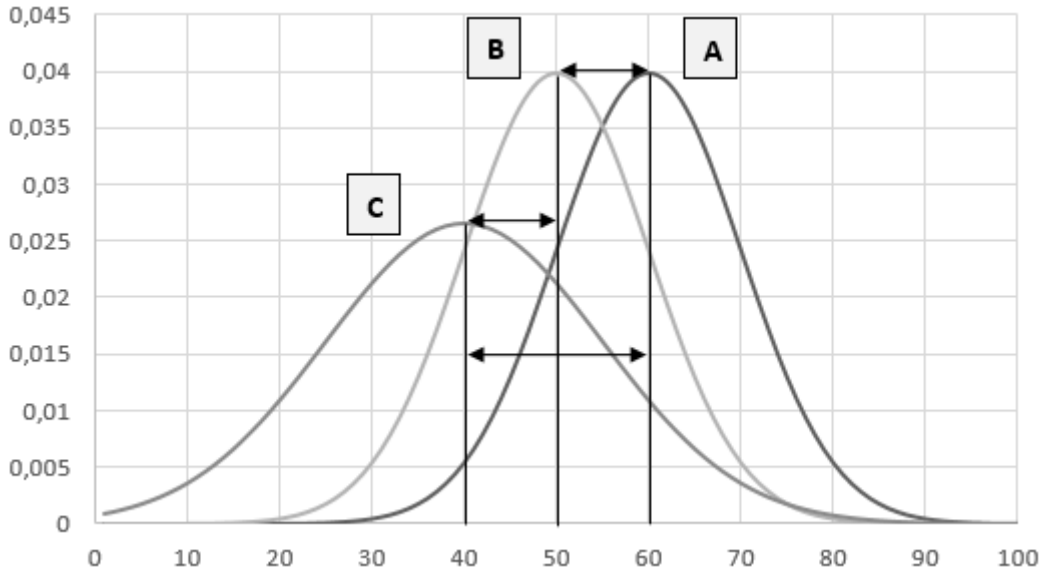


Figure 3.4 Simple bell-curve illustration of ANOVA

The overall triage system performance was evaluated in terms of its reliability and validity.(23–27,40) As discussed in the literature review, reliability addresses the consistency of a triage system and is measured by its precision, whereas validity addresses and is measured by its accuracy. The statistical tools to measure precision and accuracy are further described in chapters 5 and 8. In summary, based on the literature reviewed on similar studies of this nature it was decided to use Cohen's Kappa, Fleiss Kappa and inter-class correlation coefficients to determine the precision of the triage systems, and the confusion matrix including over-triage and under-triage to determine the accuracy of the triage systems (Figure 3.5). The confusion matrix is a table that is often used to described the performance of a classification model and is discussed further in chapter 5.(62,198–201) A common method in comparing predictive performance and overall accuracy from such binary classifiers is that of receiver operating characteristics (ROC).(80,82,100,202) In short, a curve is established based on the cumulative relationship between a system's sensitivity and its specificity. From there, the area under the curve (AUROC) is calculated. (80,82,100,202) It was however found that this type of analysis was not suitable to compare triage system performances as the ranked triage categories did not allow for proportional curves to be created.

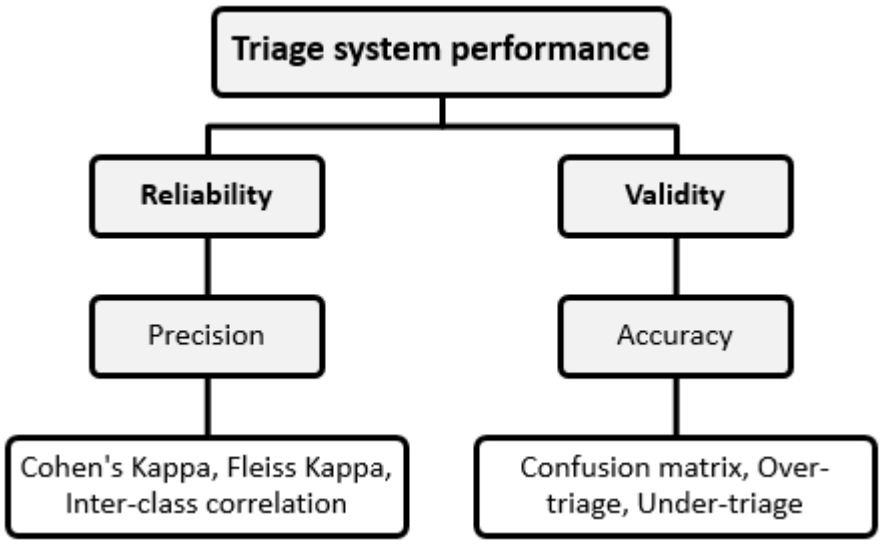


Figure 3.5 Triage system performance measures organogram

A large portion of this research project involved the comparison of performance indicators across different triage systems. In chapter 5, the existing international triage systems were compared against each other. In chapter 8, the developed version 2 of the novel Mediclinic Middle East triage system was compared to the overall performance of the existing triage systems. Comparing different triage systems to each other is a notable limitation that may have introduced biases to the project. These biases are evident from the literature for the following reasons: each triage system was intended to meet the needs of a unique patient demographic with a specific injury and illness profile; the permitted capabilities of the individuals applying these triage systems vary between healthcare authorities; the triage category definitions of the five-level triage systems vary; each triage system has its own unique approach to what it finds important within triage (e.g. acuity versus resource driven). It would be nonsensical to purely compare performance indicator numbers from these triage systems against each other as the spectrum of diversity is broad. Studies from the literature have shown similar difficulty in direct comparisons of triage systems, however it is possible to do so if variables are controlled.(15,17,22)

In chapter 5, the triage systems were applied to the same testing population by using previously agreed upon, fixed, locally appropriate, triage priorities attached to each simulated, patient vignette. This rendered comparable triage categories irrespective of which one of the existing triage systems was applied. What was compared was therefore not the triage system side-by-side, but each systems' ability to triage the vignettes (i.e. fixed triage priority), appropriately. This enabled an indirect comparison of how these triage systems are applied in practise and how they perform in the Mediclinic Middle East EC environment. In other words, the application of the system to a predetermined reference standard was tested rather than the outright ability of the system to recognise a correct triage priority (Figure 3.6). This indirect method of analysis allowed for a direct comparison of how the systems were applied in this environment. By evaluating how the systems were applied within the ECs, it was possible to determine which triage system was best suited to this environment. Using baseline performance indicators of how the existing international triage systems have been applied, we were able to evaluate version 2 of the novel

Mediclinic Middle East triage system's performance. We compared and ultimately evaluated and determined whether the novel triage system was a better fit to the local environment than the existing triage systems.

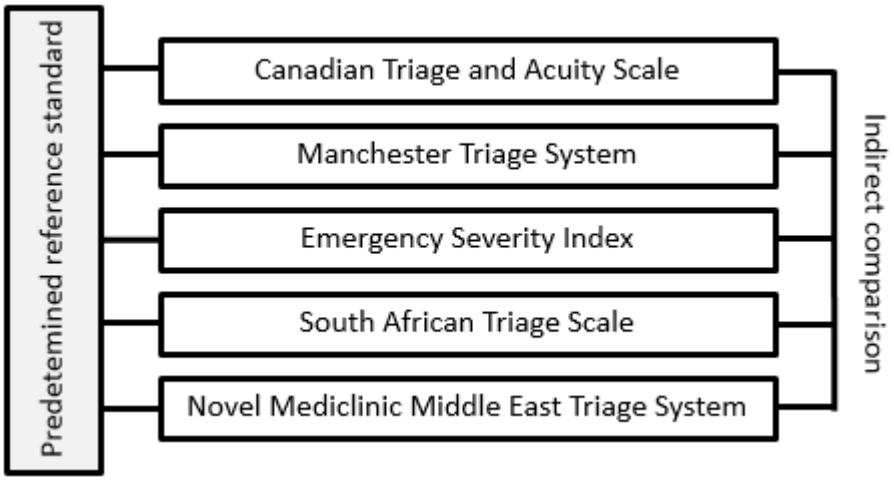


Figure 3.6 Indirect comparison based on a predetermined reference standard

Many of the studies within this thesis are quantitatively designed; measurable and analysable within the statistical domain. A further part of this project and the fundamental piece within action research was qualitative analysis through the collaboration with stakeholders. The statistical data provided the information necessary for the stakeholders to make informed decisions in the developmental process. The qualitative analyses methods are described in further detail in chapter 6 and are primarily based on observation and theme creation.(134,203–205)

3.10 Research approvals

This research project was approved by the University of Cape Town's Emergency Medicine Divisional Research Committee, Department of Surgery (reference EM2014/11), and Human Research Ethics Committee (reference 744/2014). The Mediclinic Middle East executive committee provided approval for the project to take place within Mediclinic Middle East facilities, simultaneously granting the researchers access to medical records as well as staff consenting to participate.

Chapter 4

4 Inside Mediclinic Middle East's emergency centres

Mediclinic Middle East, according to its senior management, makes use of four triage systems within their emergency centres (ECs) namely: the Canadian Triage and Acuity Scale, the Manchester Triage System, the Emergency Severity Index, and the South African Triage Scale.(11) These systems were developed to meet the needs of the patient demographic and environments of the countries they originated from. There has been only limited research conducted within the Middle East related to triage systems, mainly limited to a handful of papers (Chapter 2) on the implementation of the Canadian Triage and Acuity Scale within Saudi Arabian public ECs but little else.(12–14) Mediclinic Middle East has informally adopted these triage systems within its four ECs without evaluating its appropriateness and applicability to their specific EC patient demographic. With the variance in triage system outcome measures, this blinded implementation may have opened up potential risk to patient safety and requires investigation.

4.1 Aim

The aim of this part of the thesis was to describe, compare and correlate the triage allocations at the four Mediclinic Middle East ECs in terms of demographics, case load and principal diagnosis.

4.2 Objectives

1. To describe the demographics, case load, triage category allocations and principal diagnoses collectively and individually for the four ECs over the study period.

2. To compare and correlate triage category allocations across the four ECs over the study period.

4.3 Methods

4.3.1 Study design

An observational, cross-sectional study was conducted through retrospective evaluation of patient medical records within the four Mediclinic Middle East ECs. The STROBE statement checklist for reporting observational studies was used as a framework to report the findings presented.(185)

4.3.2 Setting, population and sample size

Medical records from patients triaged in each of the four ECs over a period of six months were evaluated. The six-month period of May to October 2014 were backdated from the date of study initiation (November 2014) which ensured the most current data at the time was used. It was expected from the outset and based on interaction with Mediclinic Middle East management prior to this study, that the EC patient population would be predominantly low acuity.(11) It seemed reasonable to collect data over a six-month period for the following reasons: to allow for the collection and inclusion of high acuity cases, the period between May and October 2014 would represent a similar patient population pattern as that experienced within Mediclinic Middle East ECs annually, the time period included seasonal change that could impact disease profiles, it included a major school holiday (July and August 2014) and it further included the holy month of Ramadan (August 2014) within the United Arab Emirates. The six-month period was thus reflective of the population movement within the United Arab Emirates as well as inclusive of possible disease dispersion.

A non-probability all-inclusive sampling method was used as the records were readily available through the Mediclinic Middle East medical records department. (130) This method was chosen above that of probability sampling as all the records were available for an accurate analysis of the patient demographic and allow for inclusion of high acuity cases which could be lost through chance.(130) It was possible through convenience sampling for the inclusion of all the possible patient records during the selected six-month period as they were easily accessible. In doing this, it was

assumed that all the records were available and complete which was then a limiting factor discussed later in this chapter. It was estimated from the average daily count of 250 – 350 patients distributed over the four ECs, that a sample of approximately 45,000 to 60,000 records was available during the selected six-month period.(11) The size and variation of the sample of patient records was not suitable for other methods such as snowball or a case study sampling.(130) With the inclusion of all records, a judgmental or a deviant sampling method was also not appropriate as this may have incurred selection bias and not have reflected the true patient population.(130)

4.3.3 Data collection

Electronically captured data from the four ECs during the months of May to October 2014 were collated by the Mediclinic Middle East medical records department. The data was provided for research purposes in a single Microsoft Excel (© Microsoft Office, Palo Alto, CA) spreadsheet in November 2014.(186) Entries from electronic data captured on each EC's information system included: patient demographics (e.g. age, gender and nationality), caseloads (as determined by case date stamps), triage category allocation and principal diagnosis. These entries were anonymised of any patient identifiers (e.g. names, surnames and medical record numbers) prior to the dataset being shared with the researcher.

4.3.4 Variables and bias

For each variable described above, the missing data points pertaining to that variable were removed from the sample prior to its analysis. The records were removed for each variable only during that variables analysis. There were no obvious reasons for data points to be missing other than random omission from the staff to make entries, and thus obtaining these missing data points would not be possible. With a reasonable loss of 10% or less among the records, the sample size was still large enough to appropriately reflect the proportions of the population. The records that were removed are reported in the results section.

4.3.5 Data analysis

Most of the data were either nominal (e.g. nationalities, gender, and principal diagnosis) or ordinal (e.g. triage category allocations) while some were not (e.g. age). Since most distributions were skewed, non-parametric descriptive statistics were used with the median as a measure of central tendency. Histograms and frequency tables were also used to describe distributions.

Patient's demographics and principal diagnoses were captured during the patient's journey through the EC and were not affected by the triage system applied. It was known prior to data collection that the four ECs used different triage systems either exclusively or in combination.(11) Although there might have been a predominant triage system advocated by each EC, the actual application by the person conducting triage may have varied. As previously described, all the triage systems used in the four ECs were five-level systems. The different triage systems each consisted of five possible triage categories, for which, priorities were defined relative to that specific triage system.(56–59) This study quantified the triage category allocations irrespective of the triage system applied. These were used as reference points later on in this thesis. The evaluation of triage category allocations was an important part of this study.

To determine the variance of triage category allocations between the four ECs an analysis of variance (ANOVA) test was applied. A single-factor ANOVA, without replication and with a precision level of $p<0.05$, was applied to the total allocations each triage category received at each EC. As described in chapter 2, the ANOVA test is a parametric measure. However, lacking an alternative, its robust nature against violated assumptions and its use in similar triage studies made it an ideal measure to test the null hypothesis.(15,117,190,195,206,207) The null hypothesis is a model that usually states a default position of showing no difference between specified populations.(188,190) By rejecting the null hypothesis, there may be grounds to state that there is a significant difference between the specified populations.(188,190) There is a limitation to applying the ANOVA test to the triage categories as

they represent levels of acuity and thus have a ranked value: one (i.e. highest acuity) to five (i.e. lowest acuity).(190,207) The purpose of applying the ANOVA test was to determine whether there was significant variation between the means of the factors and not the variation based on ranked acuity levels. Although two factors existed (e.g. triage category and EC), the limitation of a ranked factor (e.g. triage category) was not suitable for a two-factor ANOVA analysis. The assumption was that triage category allocations varied greatly by nature and thus evaluating the variance of the mean between them would have provided false results. This was also not an appropriate tool to describe the sample as the variance in categories each represented very different populations. What could be done however, was to evaluate the differences between ECs as they were not ranked. Interpreting the ANOVA result in combination with a Spearman's correlation coefficient that took into account the ranked acuity provided the best measure of how the triage categories were allocated between the ECs.

The null hypothesis was that there was no significant difference in the triage category allocations of the four ECs. The ANOVA test provided two outcome measures that we were able to apply to evaluate whether the null hypotheses was rejected. The p-value showed the probability of how extreme the observed result was against what was being tested for.(190,207) If the p-value was lesser than the significance level then the null hypothesis could be rejected; if the p-value was greater than the significance level then the null hypothesis could not be rejected, however, but that did not prove it was true.(190,207) The F-value compared the total deviation of the factors by dividing the variance between the factors with the variance within the factors.(190,207) A critical F-value was derived from the data and was based on the pre-set significance level. When the F-value was greater than the F-critical, the null hypothesis could be rejected; if the F-value is lesser than the F-critical then the null hypothesis could not be rejected, but that did not prove it was true.(190,207) To determine the correlation of triage category allocations among the four ECs, a Spearman's correlation coefficient test was applied. A two-tailed test, to determine relationship in both directions, with a precision level of $p<0.05$ was applied to the total allocations each triage category received at each EC. In contrast to the ANOVA,

the Spearman correlation coefficient did not test the variance of the means but evaluated the relationship between the factors.(190,207) Spearman's correlation coefficient (non-parametric) was similar to the Pearson correlation coefficient (parametric) but took into account the applied rank of the factors.(190,207) The correlation among the four ECs regarding their triage category allocations was tested with the triage category as the ranked factor.

4.4 Results

4.4.1 Sample description

There was a total of 56984 patient records captured from the four ECs, from May to October 2014. Missing data points identified were: nine (<0.1%) records missing gender, 2001 (3.5%) record missing principal diagnosis, and 2602 (4.6%) records missing triage category allocation (Table 4.1).

Table 4.1 Data variables collected from patient records at the four emergency centres (May to October 2014) (n=56984)

Data variable	Records available	Proportion
	n	%
Nationality distribution	56984	100
Age and gender distribution	56975	99.9
Principal diagnosis profile	54983	96.5
Triage category allocation	54382	95.4

4.4.2 Patient caseload

During the six-month period from May to October 2014, the two hospital ECs saw the vast majority, 48224 (84.6%), of patients, with the clinics only seeing a small portion, 8760 (15.4%), of patients (Table 4.2). An overall monthly median of 9419 (interquartile range 8510 – 10483) patients visited Mediclinic Middle East's ECs. The number of patients seen between the four ECs was of similar proportional median; the difference in interquartile range was between 0.00 – 0.03 per EC each month.

Table 4.2 Patient record distribution at the four emergency centres (May to October 2014) (n=56984)

Emergency centre	Total	Median (IQR)	Proportion
	n	n (Q1 – Q3)	%
Welcare hospital	27512	4402 (4110 – 5026)	48.3
City hospital	20712	3434 (3091 – 3856)	36.3
Al Sufouh clinic	5191	879 (775 – 982)	9.1
Ibn Battuta clinic	3569	642 (527 – 659)	6.3

IQR, interquartile range; Q, quartile

4.4.3 Patient nationality distribution

Of the 56984 records available with patient nationality data, a total of 173 nationalities were recorded with 42276 (74.2%) representing the top ten nationalities (Table 4.3). The largest, single population group was Emirati, from the United Arab Emirates (n=12361; 21.9%). The Indian population (n=9158; 16.1%) was the only other nationality that came close to matching the Emirati population.

Table 4.3 Top ten nationalities from patient records at the four emergency centres (May to October 2014) (n=56984)

Rank #	Nationality	n	%
1	Emirati	12361	21.9
2	Indian	9158	16.1
3	Filipino	3587	6.3
4	British	3219	5.7
5	Pakistani	3117	5.5
6	Jordanian	3080	5.4
7	Egyptian	2698	4.7
8	Lebanese	2529	4.4
9	Syrian	1311	2.3
10	American	1216	2.1

4.4.4 Patient age and gender distribution

Of the 56975 records available with patient age and gender data, the gender distribution was nearly equal with 28824 (50.6%) female and 28151 (49.4%) male records (Figure 4.1). There were only two age-groups that stood out; 0 – 4 years and 30 – 34 years with 10041 (17.6%) and 10186 (17.9%) records, respectively. The age group considered to represent children (i.e. 0 – 10 years) consisted of 13959 (24.5%) records and the age group considered to be the workforce (i.e. 20 – 50 years) consisted of 35187 (61.8%) records; together they made up 49146 (86.3%) of the entire patient demographic. The median age was 29 years with an interquartile range of 10 to 37 years.

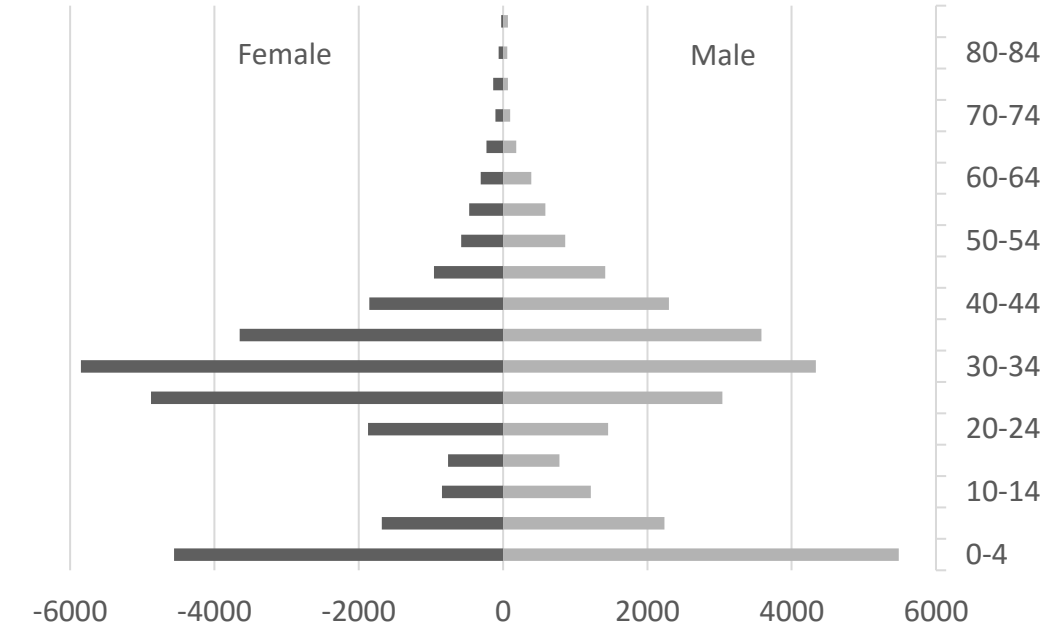


Figure 4.1 Age and gender distribution from patient records at the four emergency centres (May to October 2014) (n=56975)

4.4.5 Principal diagnosis profile

Of the 54983 records available with patient principal diagnosis data, it was found that the largest single diagnosis reported during the study period was acute upper respiratory infection (n=7940; 14.4%) (Table 4.4). The data reported from the

medical records were specific with respect to names of the diagnoses, thus certain conditions could have been captured under different names within the patient record system. For example, acute pharyngitis (n=2191; 4.0%), acute nasal-pharyngitis (n=879; 1.6%), and acute tonsillitis (n=1346; 2.5%) could have all been grouped under the name "acute upper respiratory infections", bringing the total cases to 12356 (21.7%). The same would apply to abdominal pain, chest pain, headache and fever.

Table 4.4 Top principal diagnoses from patient records at the four emergency centres (May to October 2014)

	Triage category one (n=13)		
	Acute coronary thrombosis not resulting in myocardial infarct		
	Cardiac arrest		
	Closed fracture at base of skull		
	Dizziness and giddiness		
	Haemoptysis		
	Kidney failure		
	Non-ST elevation myocardial infarction		
	Other disease and conditions complication in pregnancy/childbirth		
	Other seizures		
	Poisoning by benzodiazepines. intentional self-harm		
	Simple febrile convulsions		
	Unspecified convulsions		
	Unspecified other		
#	**Triage category two (top five, n=1748)**	**n**	**%**
1	Acute upper respiratory infection	235	13.4
2	Fever	117	6.7
3	Acute tonsillitis	106	6.0
4	Acute pharyngitis	71	4.0
5	Chest pain	56	3.1

#	All triage categories (top five, n=54983)	n	%
1	Acute upper respiratory infection	7940	14.4
2	Acute pharyngitis	2191	4.0
3	Abdominal pain	1996	3.6
4	Fever	1801	3.3
5	Infectious gastroenteritis and colitis	1557	2.8

4.4.6 Triage category allocation

Of the 54382 records available with patient triage category allocations data, triage category four was allocated most often (n=24911; 45.8%). Conversely, category one was only allocated 13 (<0.1%) times (Table 4.5 and Figure 4.2). The majority of allocations were made toward the mid to low acuity spectrum (i.e. categories three to five) (n=52513; 96.6%), whereas high acuity cases (i.e. categories one and two) only made up a low proportion of allocations (n=1869; 3.4%). The p-value (p=0.18) was more than the precision level of p<0.05 and the F-value (F=1.86) was less than the F-critical (Fcrit=3.24) (Table 4.6). Correlation among the four ECs was high (Table 4.7). Welcare hospital, Al Sufouh clinic and Ibn Battuta clinic reported close correlations, however, City hospital did not correlate with these ECs (Figure 4.3).

Table 4.5 Triage category allocation distribution from patient records at the four emergency centres during (May to October 2014) (n=54382)

	WH	CH	CS	IB	Total	
Total	**25391**	**20343**	**5149**	**3499**	**54382**	
Category	**n**	**n**	**n**	**n**	**n**	**%**
1	0	13	0	0	13	0.02
2	20	1833	3	0	1856	3.4
3	3909	8364	278	44	12595	23.2
4	14685	6627	1986	1613	24911	45.8
5	6777	3506	2882	1842	15007	27.6

WH, Welcare hospital; CH, City hospital; CS, Al Sufouh clinic; IB, Ibn Battuta clinic

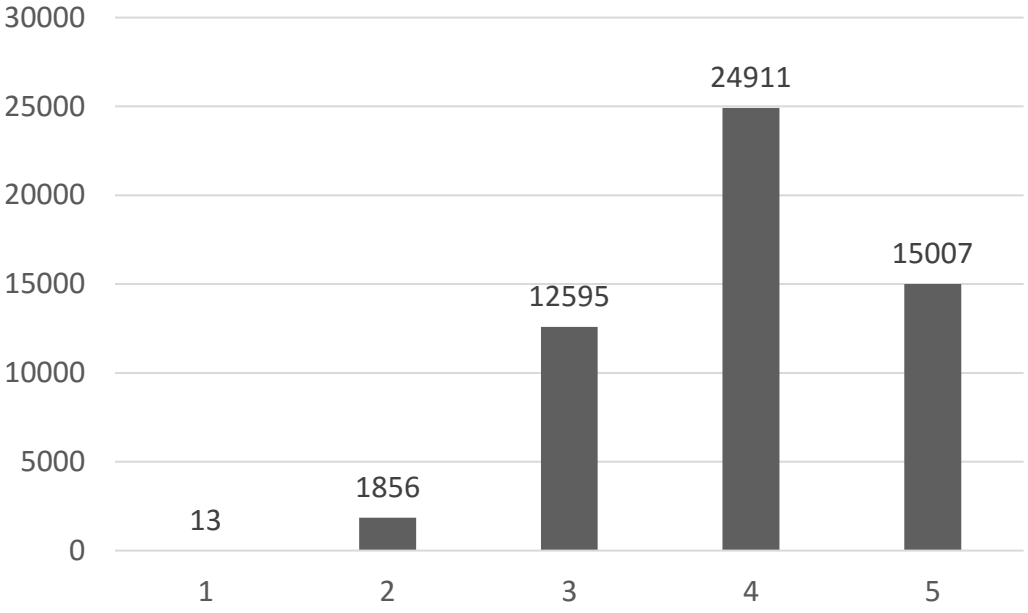


Figure 4.2 Triage category allocation from patient records at the four emergency centres (May to October 2014) (n=54382)

Table 4.6 ANOVA* of the triage category allocation distribution from patient records at the four emergency centres during (May to October 2014)

Source of variation	F-distribution	p-value	F-critical
Emergency centres	1.860	0.177	3.239

ANOVA, analysis of variance; *, single-factor without replication and alpha 0.05

Table 4.7 Spearman's correlation* of the triage category allocation distribution from patient records at the four emergency centres (May to October 2014)

	WH	CH	CS	IB
WH	-	0.70	0.90	0.87
CH	0.70	-	0.60	0.56
CS	0.90	0.60	-	0.97
IB	0.87	0.56	0.97	-

WH, Welcare hospital; CH, City hospital; CS, Al Sufouh clinic; IB, Ibn Battuta clinic; *, two tailed coefficients with alpha 0.05

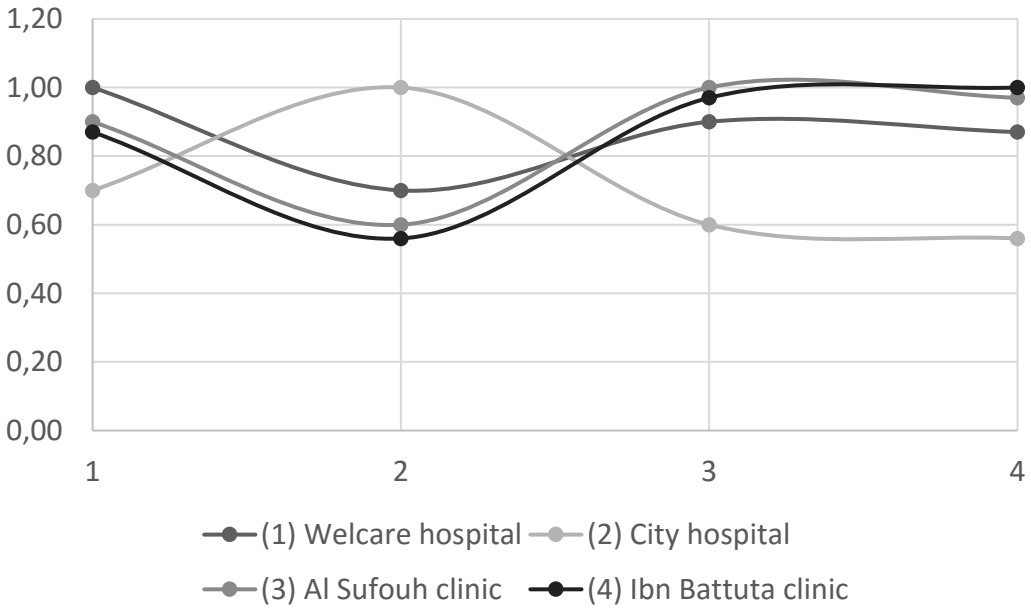


Figure 4.3 Spearman's correlation of the triage category allocation distribution from patient records at the four emergency centres (May to October 2014)

4.5 Discussion

A key finding of this part of the thesis was that the overall acuity level of the patient population seen at the four ECs was low (Tables 4.4, 4.5 and Figure 4.2). This was substantiated by the diagnoses profile which indicated traditionally lower acuity principal diagnoses (Table 4.4). The amount of high acuity cases overall (i.e. categories one and two) was very low when compared to other triage studies. This was so for the existing triage systems; they reported much higher numbers of high acuity triage category allocations elsewhere.(15,40,72,80,94,110,111,117,208) The way in which the international triage systems were applied was meant to capture the highest acuity patients first and then scale downwards allowing for the safety of over-triage in the process.(56–59) City hospital was the only EC that had notable numbers of high acuity cases, which could be contributed to its patient drainage area, situated within Dubai Healthcare City. Incidentally, and will be discussed later on in this thesis, they were the only one of the four ECs that use the Manchester Triage System. The reason remains unclear and this study was not particularly designed for this purpose.

National health regulations within the United Arab Emirates prevents private healthcare facilities from seeing major trauma cases. Trauma alone contributes substantially to the volumes of high acuity cases within international ECs.(8–10) There is no data available to compare Mediclinic Middle East EC acuity levels with other private hospital groups within the United Arab Emirates as no published research (Chapter 2) could be found. This can also not be found in grey literature from local health authority reports as data on the level of acuity seen in public ECs are withheld. The studies conducted on the implementation of the Canadian Triage and Acuity Scale in Saudi Arabian ECs did not include private care samples, furthermore their samples consisted of a different acuity presentation than this study.(12–14)

Incidentally, it was found that the South African Triage Scale was not used within any of the four ECs at the start of this project. It has not been in use for some time according to the EC nursing staff and unit managers, as informed to the researcher during the course of this study. It was therefore deemed reasonable to remove the South African Triage Scale from the list of existing triage systems in use by Mediclinic Middle East ECs. It would be difficult to directly compare the triage category allocations of the three triage systems used within Mediclinic Middle East ECs against that of other studies done as the circumstances and environments are so different. Instead, a comparison was done to evaluate the variance and relationship of the triage category allocations between the four ECs. The ANOVA revealed no significant variations (Table 4.6) and the null hypothesis could thus not be rejected.(190,207) Although the null hypothesis could not be rejected, it does not indicate that the hypothesis is absolutely true.(190,207) It simply denotes that the means of triage category allocations were similar. To establish the relationship of triage category allocations among the four ECs a Spearman's correlation coefficient test was applied (Table 4.7). These results showed that three of the four ECs correlated well, with similar distribution of their triage category allocations. One EC, City hospital, did not correlate well with the others (Figure 4.3). The specific cause for this aberrance is unknown, as it could have come from the triage system used, the patient population or the operators themselves.

Looking at the distribution of patients across the four ECs, the two hospitals saw considerably more patients than the smaller clinics (Table 4.2). The proportion of patients seen at each EC over the six-month period was the same, irrespective of the overall volume of patients, and suggested a stable and predictable distribution of patients across the four ECs each month. This was anticipated since the larger hospital ECs had more resources available to provide extensive treatment regimens than the clinic ECs.(11) This result may also have been due to patients' presumption that the hospitals were better suited for emergencies than the clinics. The location of the hospitals was also more readily accessible and nearer to the city centre of Dubai (Figure 1.2, Chapter 1). With a total of 56984 patients seen at the four ECs during the six-month period, considerably fewer patients were seen at the five public ECs in the same region, which was approximately 150,000 to 160,000 patients.(6,7) This lends the notion that the triage demand on the four ECs is not very high and therefore the triage system used would be under considerably less strain on a day-to-day basis.

The overall nationality distribution was a direct reflection of the resident population within the United Arab Emirates (Table 4.3).(6,7) The number of Emirati, nationals from the United Arab Emirates, that visited the four ECs are in line with population statistics, however, this was contrary to perceptions within Mediclinic Middle East management who believed native Emirati population made up a significantly small proportion of its overall EC patient visits.(11) The patient age distribution indicated a large patient population between the ages of 20 and 50 (Figure 4.1). According to the World Health Organisation's annual Statistics report of 2014, this type of distribution is characteristic of both lesser and more developed regions.(209) This large workforce group can be attributed to the fact that the largest number of residents within the United Arab Emirates are expatriates that come for work opportunities, and are among one of the largest contributors to the United Arab Emirates' economy.(1,6,7) Local governmental regulations also do not favour residents remaining within the country after retirement, and thus most expatriates will leave the United Arab Emirates at an older age.(1) With this workforce turnover, there may be a skewed and possibly artificially created population distribution. The

large female patient population is also contrary to the overall United Arab Emirates population statistics that indicate a male to female ratio of at least three to one.(6,7) A possible reason for this difference takes into account that the vast majority of the male expatriate population are low-income workforce labourers that do not have access to the private healthcare that Mediclinic Middle East offers. The nationality, age and gender distributions may not have a direct impact on the triage system used, although it may have indirect consequences that may alter the application of a triage system. With the majority of patients being adults in the working stages of life, the triage system used is not as affected by outlying patient populations, i.e. children or the elderly. It is not certain what impact these factors would have on a local triage system. Further research is required to fully understand how these factors could impact the novel triage system intended for Mediclinic Middle East ECs.

4.5.1 Limitations

Extracting information from a database does bring with it some limitations as to the authenticity and validity of the data provided. These were mitigated by the knowledge that Mediclinic Middle East's records were secure and were also used for the purposes of analysis within the business as well as reporting to the local health authorities. The data was the best possible reflection of the records as captured within the four ECs and were secured through the Mediclinic Middle East's medical records department. The possibility of missing data points was anticipated but with only three variables showing small proportions of absent data points (gender 0.02%, triage category allocation 4.6% and principal diagnosis 3.5%), it was very unlikely that this undermined the results of this study.

During the analysis of principal diagnoses, it was found that the diagnoses names within the records were very specific. Each entry was thus subjected to the individual physician's preference on which diagnosis name to use. Certain diagnosis names reflected very similar conditions or groupings thereof. For example, acute pharyngitis and acute nasal-pharyngitis could have been grouped under acute upper respiratory infection, gastroenteritis could also reflect as abdominal pain, and fever could

represent a vast array of conditions. The purpose of the principal diagnosis evaluation was to establish a general overview of the common illnesses treated within the four ECs and to determine what level (i.e. high or low) the illness' acuity could predominantly be associated with.

Evaluation of triage category allocations among the four ECs was difficult as they use different triage systems, either exclusively or in combination for the determination of patient triage categories. Although all the triage systems were considered five-level triage systems by definition, it was found that the South African Triage was actually a four-level system when compared to the other three systems. It was not known at the time of this study but it was found later on in this project that none of the ECs actually used the South African Triage Scale. It was therefore highly unlikely to find this particular system applied to determine triage categories. Thus, only the three remaining five-level triage systems were compared. Direct comparisons of the triage categories were avoided as that would be like comparing apples with pears. However, evaluations among the four ECs were possible to measure how the ECs applied their triage systems to the patient population. It was thus the distribution of the five triage levels and not their content that was evaluated.

4.6 Chapter summary

This study has shown that the vast majority of patients that presented to the four Mediclinic Middle East ECs had low acuity illness profiles and were subsequently allocated lower triage categories. There was an overall low demand on the triage process on a daily basis within the four ECs, however, this was dependant on their day-to-day patient volumes. There were inconsistencies related to the number and distribution of triage category allocations between the three ECs that used the Canadian Triage and Acuity Scale and the EC that used the Manchester Triage System. Incidentally, it was found that the South African Triage Scale was not in use at any of the four ECs, and could be removed from the list of existing triage systems. These results favours the mandate from Mediclinic Middle East to standardise a single triage system.

Chapter 5

5 Triage in Mediclinic Middle East's emergency centres

The demographics of Mediclinic Middle East's emergency centre (EC) patients, their triage category allocations and their diagnosis profiles were described in chapter 4. Following this, an evaluation of the existing triage systems needs to be performed from a healthcare provider's perspective. An evaluation that focuses on the reliability and validity indicators that was discussed in the literature review.

> *Reliability is the understanding of a triage systems precision to consistently allocate similar triage categories to related patient presentations.*(23–25,90–93)
>
> *Validity is the understanding of a triage systems accuracy in determining the correct triage category for the correct patient presentation.*(15–19)

The reliability and validity of the various, existing triage systems within the context of Mediclinic Middle East's EC environment had not previously been evaluated. To determine the single, standardised, locally appropriate triage system required, it is necessary to understand the overall performances of the different systems, namely: the Canadian Triage and Acuity Scale, the Manchester Triage System, the Emergency Severity Index.(11) It is also necessary to determine what the relationship of the reliability and validity is among the four ECs.

5.1 Aim

The aim of this part of the thesis was to describe the reliability and validity of the existing triage systems used within and between all four Mediclinic Middle East ECs, utilising a bespoke reference standard.

5.2 Objectives

1. To construct a reference standard in the form of written case-based vignettes, validated for priority.

2. To describe the reliability and validity of the existing triage systems used at all four ECs using the bespoke reference standard from objective 1.

3. To compare the reliability and validity of the existing triage systems used within and between the four ECs using the bespoke reference standard from objective 1.

5.3 Methods

5.3.1 Study design

An observational, cross sectional study was carried out by prospectively evaluating the reliability and validity of the existing triage systems within the four ECs. This was done by means of an automated, anonymised survey. A bespoke reference standard in the form of priority-validated case scenarios (i.e. vignettes) were used for this evaluation. Similar studies have used variable amounts of vignettes, from ten up to 100, with an average of 50 for their evaluations, dependent on time availability and participant numbers.(42,62,69,74,85,94,124) The three triage systems used in the four ECs were all five-level systems. As a result, ten vignettes were constructed for each of the five triage priorities (highest to the lowest) resulting in a total of 50 vignettes (Appendix A). The vignettes were based on the training vignettes in the official training manuals of the three triage systems.(56–59) They were then amended to conform with the locally appropriate patient presentations, identified in chapter 4, in order to be representative of the Mediclinic Middle East EC patient population. Findings from chapter 4 indicated that patient population and acuity levels varied greatly between the Mediclinic Middle East EC environment and those reported in other validation studies.(15,40,72,80,94,110,111,117,208) The vignettes were carefully written to ensure that all the required triage information was available, irrespective of which triage system was objectively applied. Next, the vignettes were prioritised on a five-level acuity scale. A panel of eight experts (see below) was asked to validate the constructed vignettes' priority through a three-round, internal consensus process. Experts included experienced clinicians from within Mediclinic Middle East who were recognised as local triage experts based on their knowledge of the patient population, their understanding of the acuity

distributions within the four ECs and their involvement in triage training. The vignettes, with their priorities, were sent to the experts who reviewed their appropriateness and indicated whether they agreed with the priority setting. Once all the experts were in agreement with the priority allocated to each vignette, they were accepted as the reference standard for this study. The limitations of this method is discussed later.

5.3.2 Setting, population and sample size

All registered nurses who perform triage within any of the four ECs were invited to participate. Given the small size of the potential participant pool, an all-inclusive sample was employed. At the time, approximately 69 registered nurses who regularly practiced triage was employed between the four ECs. It was expected that the majority would agree to participate in the study. As per the study protocol, nursing staff were contacted and invited to participate a month (March 2015) prior to the start of data collection. At the same time, a research information sheet (Appendix B) was distributed to provide an overview of the research plan. The information sheet stressed that participation in the study would greatly advance the success of this project, that participation was entirely voluntary, that contributions would be anonymous, and that participation would not have any negative influence on employment with Mediclinic Middle East. Nurses who agreed to participate were enrolled and as per the study protocol and provided with a more extensive participant information sheet (Appendix C). This was followed by completion of the participant informed consent form (Appendix D) and then the survey. Participants were informed that consent would remain intact, as per the study protocol, for the entire duration of this project, including the subsequent studies conducted in chapters 6 and 8. While participation in this study did not compel participation in the subsequent studies within chapters 6 and 8, further participation was encouraged to contribute to the success of the project.

5.3.3 Data collection

The data were collected using the online survey platform: SurveyMonkey (© SurveyMonkey, Palo Alto, CA).(187) Unique access links were automatically generated by the software and emailed to each participant via their organisational email address. Following the completion of the informed consent form, participant demographics were collected at the beginning of the survey. The demographics included: age, gender, nationality, level of qualification, years of experience as a registered nurse, years of experience within Mediclinic Middle East ECs, current Mediclinic Middle East EC place of employment, years of triage experience and a triage skill self-assessment (Table 5.1).

Table 5.1 Triage skill self-assessment ratings and their descriptors

Skill self-assessment rating	Rating descriptor
5	Specialist skill with triage
4	Above average skill with triage
3	Average skill with triage
2	Below average skill with triage
1	Little to no skill with triage

In evaluating the vignettes, participants were instructed to allocate the relevant triage category according to the five-level existing triage system at their respective EC. Triage allocations, irrespective of system, could therefore be provided in a similar format (Table 5.2). Data collection was conducted over a two-week period from 26 April until 10 May 2015, and will further on be referred to as vignette study one. The surveys were completed under the supervision of the unit managers. They allocated a workstation away from the unit's common area for the surveys to be completed. The unit managers allowed for one participant to complete the survey at a time. Participants were allowed to complete the survey only once and at a suitable time during working hours. Participants were instructed to complete the survey alone in one sitting, with each vignette estimated to take a maximum of 2-3 minutes to

complete. Short rests or bathroom breaks no longer than 10-15 minutes were allowed for participants' comfort and to avoid fatigue. The participants were briefed not to discuss the vignettes during such breaks. Participants were not allowed any other external assistance and their mobile phones were kept, with their permission, by the unit managers during survey completion. At the end of the two-week period (12h00 on 10 May 2015), the survey was closed and data were extracted for analysis.

Table 5.2 Triage categories and their descriptors

Triage category	Triage descriptor
1	Critical / Resuscitation
2	Very urgent / Emergent
3	Urgent
4	Routine / Less-urgent
5	Non-urgent

5.3.4 Variables and bias

There were three triage systems believed to be in use at the time of the study within the four ECs (i.e. the Canadian Triage and Acuity Scale, the Manchester Triage System, the Emergency Severity Index). Although all of these are five-level triage systems, their differences as discussed in chapter 2, make it difficult to directly compare their performances. There was also uncertainty as to exactly which triage system or combinations were being used and where. Participants provided information about the triage systems in use in each EC. This information made it possible to compare the specific triage systems against the reference standard (i.e. vignettes). As previously described, the construct of the vignettes, each with a priority fixed at one of five levels, allowed application of any of the five-level existing triage systems. The relationship of the triage systems to the reference standard thus became comparable. This, as least in part, helped reduce the subjective bias of the triage systems.

5.3.5 Data analysis

The performance of a triage system is determined by its reliability and validity. This study used performance indicators based on a confusion matrix to determine the validity of the existing triage systems within the four ECs (Table 5.3).(62,198–201) Analysis included sensitivity, specificity, accuracy, diagnostic odds ratio, as well as over-triage and under-triage. The latter two were calculated with indicators derived from the confusion matrix. The indicators were included in the results section as they provided the most relevant and pertinent results. Other indicators such as fall-out rates, miss rates, predictive values, false omission rates, false discovery rates, prevalence and likelihood ratios are presented in Appendix E. These indicators were no less valuable, but provided similar results which did not add any additional information. Analysis was performed using the latest version of Microsoft Excel with a statistical add-in analysis tool from Real Statistics (© Charles Zaiontz, Trento).(186,207) The reliability and validity indicators were described using a 95% confidence interval.

A search of the literature (Chapter 2) revealed no universally accepted standards, norms or guideline values to reference the performance indicators against. This may be due to the difficulty of transposing such reference guidelines across a wide range of healthcare applications, specially to triage where the system and environment dramatically affect the outcome measures. What can be done is a comparison of one value to another and then a description of which is better, or a comparison of the findings against similar studies.(18,24,55,62,69,77,80,117) It is accepted that a reference guideline should consider the acuity level ranking and thus each triage category (Table 5.2) should ideally have its own reference standard. This is the first study of its kind within the Mediclinic Middle East EC environment and as a result of the unknowns related to the existing triage systems, it was decided *a priori* to use the hypothetical reference standard as presented by Landis and Kock (1977) (Table 5.4).(99)

The performance indicator results of this project should inform further studies and the establishment of a unique reference guide suited to the Mediclinic Middle East EC environment. Over- and under-triage are performance indicators specific to the study of triage systems. They are used to determine whether acuity levels are given a higher or lower triage category than expected. The American College of Surgeons Committee on Trauma (ACSCOT) considers a system to be acceptable when under-triage is not more than 5-10% and over-triage not more than 30-50%.(62) This, however, cannot be directly applied to this study as it has been identified in chapter four that Mediclinic Middle East ECs do not see major trauma. However, these values can be used as a rough guide for comparison as they are widely used in other triage studies.(62,63,87)

This study used agreement and association indicators to determine the reliability of the existing triage systems within the four ECs. These indicators included inter-rater Cohen's Kappa (i.e. two raters) and Fleiss Kappa (i.e. multiple raters) statistics and inter-class correlation as described in the literature review (Chapter 2). The agreements between the participants and the experts were made for each triage category using the two-by-two framework of the confusion matrix. This was repeated for all triage categories using the five levels to establish an overall five-by-five framework. The two-by-two framework only allows for unweighted Cohen's Kappa, whereas the five-by-five framework allows for weighting (e.g. linear and quadratic) of the triage category acuity levels. Weighting Cohen's Kappa allowed for ranking values to be allocated to the triage categories based on their acuity levels. The inter-rater agreement between the participants was determined using Fleiss Kappa which allowed for a multi-rater calculation. The agreement between the participants was thus calculated over all 50 vignettes and triage categories. The correlation between the participants and their triage category allocations was done using an inter-class correlation coefficient to determine whether the 50 vignettes could be reliably triaged by the different participants. Interpretation of the agreement and association indicators were subject to the guidelines as set forth by Landis and Kock (1977) and used frequently as reference guidelines by other studies of this kind (Table 5.5).(23,24,26,40,42,74,99,110,111,210)

Table 5.3 The confusion matrix statistical analysis model as applied in this thesis (200,201)

		Expert Reference Standard			
	Total Vignettes	Category Positive	Category Negative	Prevalence = Category Positive / Total Vignettes	
Participant Rater	Allocation Positive	True Positive (TP)	False Positive (FP)	Positive Predictive Value (PPV), True Positive / Allocation Positive	False Discovery Rate (FDR) = False Positive / Allocation Positive
	Allocation Negative	False Negative (FN)	True Negative (TN)	False Omission Rate (FOR) False Negative / Allocation Negative	Negative Predictive Value (NPV) = True Negative / Allocation Negative
	Accuracy (ACC) = True Positive + True Negative / Total Vignettes	True Positive Rate (TPR), Sensitivity = True Positive / Category Positive	False Positive Rate (FPR) = False Positive / Category Negative	Positive Likelihood Ratio (LR+) = TPR / FPR	Diagnostic Odds Ratio (DOR) = LR+ / LR-
		False Negative Rate (FNR) = False Negative / Category Positive	True Negative Rate (TNR), Specificity = True Negative / Category Negative	Negative Likelihood Ratio (LR-) = FNR / TNR	

TP, true positive; FP, false positive; PPV, positive predictive value; FDR, false discovery rate; FN, false negative; TN, true negative; FOR, false omission rate; NPV negative predictive value; ACC, accuracy; TPR, true positive rate; FPR, false positive rate; LR+ positive likelihood ratio; FNR, false negative rate; TNR, true negative rate; LR-, negative likelihood ratio; DOR, diagnostic odds ratio

Table 5.4 Hypothetical reference guideline of performance indicators

Indicator proportion	Strength of performance
0% – 20%	Very poor
21% – 40%	Poor
41% – 60%	Moderate
61% – 80%	Good
81% – 100%	Very good

Table 5.5 Interpretation guideline for Kappa (Cohen's and Fleiss) agreement and inter-class correlation measures (99)

Indicator value	Strength of agreement
< 0.00	Poor
0.00 – 0.20	Slight
0.21 – 0.40	Fair
0.41 – 0.60	Moderate
0.61 – 0.80	Substantial
0.81 – 1.00	Almost perfect

5.4 Results

5.4.1 Sample description

Of 69 potential participants, 59 (85.5%) were enrolled and completed the survey (Table 5.6). Of the non-participants, three were nurses that were outside the United Arab Emirates at the time of data collection and seven others did not enrol for unspecified reasons. In total there were 2950 completed scenarios with 590 in each triage category. For perspective, this equates to 31% of the median monthly patient population (n=9419) seen between the four ECs.

Table 5.6 Participant distribution

Total participants available	**69**	
	n	%
Total participant sample	**59**	86
Welcare hospital	19	32
City hospital	21	36
Al Sufouh clinic	10	17
Ibn Battuta clinic	9	15

5.4.2 Participant demographics

The ages of the 59 participants were distributed across an interquartile range of 31 to 39 years with a median of 36 years. The majority (75%) of participants were under the age of 40. The gender distribution was eight (14%) male and 51 (86%) female yielding a male to female ratio of 1:6.4. There was a total of ten nationalities recorded with the majority of participants indicating their nationality as either Filipino (n=29; 49%) or Indian (n=18; 31%) with all other nationalities (n=12; 20%) individually counting between one and three (2-5%) each. The participant qualification distribution was: diploma (n=12; 20%), advanced diploma (n=1; 2%), bachelor's degree (n=45; 76%), and master's degree (n=1; 2%). It was reflected that 37 (63%) participants received triage training through Mediclinic Middle East and 22 (37%) did not. The majority of participants (n=35, 59%) indicated they have more

than ten years of overall healthcare experience, however, they also indicated that their Mediclinic Middle East EC (n=50; 85%) and triage experience (n=53; 90%) was less than ten years (Table 5.7). The majority of participants gave themselves a triage self-assessment rating of either average (n=21; 36%) or above average (n=35; 59%) (Table 5.8).

Table 5.7 Participant (n=59) reported experience in years

	Healthcare [a]		MCME EC		EC triage	
Years	**n**	**%**	**n**	**%**	**n**	**%**
0 – 1			5	8.5	4	6.8
1 – 2			7	11.9	3	5.1
2 – 5	3	5.1	17	28.8	19	32.2
5 – 10	21	35.6	21	35.6	27	45.8
> 10	35	59.3	9	15.3	6	10.2

a, overall healthcare experience (includes MCME EC and EC triage experience); MCME, Mediclinic Middle East; EC, emergency centre

Table 5.8 Participant (n=59) triage self-assessment

Triage self-assessment		
	n	**%**
Little to none		
Below average	1	1.7
Average	21	35.6
Above average	35	59.3
Specialist	2	3.4

The Canadian Triage and Acuity Scale was the most used triage system within the four ECs (Table 5.9). In addition, it was reported that: all (n=19) Welcare hospital participants used the Canadian Triage and Acuity Scale, exclusively; 19 City hospital participants used the Manchester Triage System, with two additional participants using a combination of the Canadian and Manchester systems; all (n=10) Al Sufouh clinic participants used the Canadian Triage and Acuity Scale, exclusively; whereas all

(n=9) Ibn Battuta clinic participants used the Canadian Triage and Acuity Scale as their primary triage system, however, six participants integrate the Emergency Severity Index as an adjunctive triage system in many cases.

Table 5.9 Participant reported triage system usage

Triage System	**67**	
	n	**%**
Canadian Triage and Acuity Scale	41	69.5
Manchester Triage System	20	33.9
Emergency Severity Index	6	10.2

5.4.3 Triage category allocations

Triage category allocations by the participants (i.e. raters) were distributed closely around the reference standard (i.e. vignettes) (Tables 5.10 and 5.11). Vignettes that were incorrectly triaged mainly received a triage category allocation either one above or one below the reference standard.

Table 5.10 Overall rater versus reference standard category allocations of vignettes by percent of allocations*

Triage Category		**Reference standard (n=590 for each category)**				
		1	**2**	**3**	**4**	**5**
Raters	**1**	**441 (74.7)**	154 (26.1)	29 (4.9)	2 (0.3)	
	2	130 (22.0)	**337 (57.1)**	131 (22.2)	44 (7.5)	5 (0.8)
	3	17 (2.9)	92 (15.6)	**281 (47.6)**	233 (39.5)	58 (9.8)
	4	2 (0.3)	7 (1.2)	131 (22.2)	**249 (42.2)**	232 (39.3)
	5			18 (3.1)	62 (10.5)	**295 (50.0)**

*, all values are numbers (percent) (i.e. n (%)) of allocations where columns may not add to 100% due to rounding

Table 5.11 Raters versus reference standard triage category allocations of vignettes per EC by percent of allocations*

Welcare hospital (n=19 participants)

Triage Category		Reference standard (n=190 for each category)				
		1	**2**	**3**	**4**	**5**
Raters	**1**	**136 (71.6)**	33 (17.4)	7 (3.7)		
	2	48 (25.3)	**101 (53.2)**	30 (15.8)	11 (5.8)	1 (0.5)
	3	5 (2.6)	52 (27.4)	**92 (48.4)**	67 (35.3)	13 (6.8)
	4	1 (0.5)	4 (2.1)	57 (30.0)	**92 (48.4)**	70 (36.8)
	5			4 (2.1)	20 (10.5)	**106 (55.8)**

City hospital (n=21 participants)

Triage Category		Reference standard (n=210 for each category)				
		1	**2**	**3**	**4**	**5**
Raters	**1**	**149 (71.0)**	59 (28.1)	6 (2.9)		
	2	53 (25.2)	**126 (60.0)**	54 (25.7)	9 (4.3)	
	3	7 (3.3)	25 (11.9)	**105 (50.0)**	87 (41.4)	19 (9.0)
	4	1 (0.5)		38 (41.4)	**87 (41.4)**	79 (37.6)
	5			7 (12.9)	27 (12.9)	**112 (53.3)**

Al Sufouh clinic (n=10 participants)

Triage Category		Reference standard (n=100 for each category)				
		1	**2**	**3**	**4**	**5**
Raters	**1**	**76 (76.0)**	24 (24.0)	5 (5.0)	1 (1.0)	
	2	21 (21.0)	**70 (70.0)**	22 (22.0)	5 (5.0)	1 (1.0)
	3	3 (3.0)	5 (5.0)	**48 (48.0)**	40 (40.0)	4 (4.0)
	4		1 (1.0)	19 (19.0)	**49 (49.0)**	53 (53.0)
	5			6 (6.0)	5 (5.0)	**42 (42.0)**

Ibn Battuta clinic (n=9 participants)

Triage Category		Reference standard (n=90 for each category)				
		1	**2**	**3**	**4**	**5**
Raters	**1**	**80 (88.9)**	38 (42.2)	11 (12.2)	1 (1.1)	
	2	8 (8.9)	**40 (44.4)**	25 (27.8)	19 (21.1)	3 (3.3)
	3	2 (2.2)	10 (11.1)	**36 (40.0)**	39 (43.3)	22 (24.4)
	4		2 (2.2)	17 (18.9)	**21 (23.3)**	30 (33.3)
	5			1 (1.1)	10 (11.1)	**35 (38.9)**

*, all values are numbers (percent) (i.e. n (%)) of allocations where columns may not add to 100% due to rounding

5.4.4 Validity indicators

The performance indicators that were found relevant to describe the validity of the existing triage systems were sensitivity, specificity, accuracy, diagnostic odds ratio, over-triage and under-triage (Tables 5.12 and 5.13). Sensitivity was highest for category one allocations with an overall rating of good, while all the other categories reached a moderate performance rating. Specificity was high across all the triage category allocations and reached an overall performance rating of very good. The accuracy of triaging allocations into categories one, two and five were high and received a very good performance rating, while allocations in categories three and four, although lower in performance, received good ratings. The diagnostic odds ratio was exceptionally high for allocations in triage categories one (i.e. highest acuity) and five (i.e. lowest acuity). Triage categories two, three and four had lower diagnostic odds ratio's however still showed that the tests are discriminating correctly. Over-triage rates were the highest for allocations in triage categories four and five and were almost double that of allocations in categories two and three. Under-triage rates were the highest for allocations in triage categories one and three with Welcare hospital having an equally high under-triage rate for allocations in category two when compared to all the other ECs.

Table 5.12 Sensitivity, specificity and accuracy proportions

Triage Category	Overall	Welcare hospital	City hospital	Al Sufouh clinic	Ibn Battuta clinic
Sensitivity [a], % (95% CI)					
1	**74.7** (71.2 – 78.3)	71.6 (65.2 – 78.0)	70.6 (64.5 – 76.8)	76.0 (67.6 – 84.4)	88.9 (82.4 – 95.4)
2	**57.1** (53.1 – 61.1)	53.2 (46.1 – 60.3)	60.0 (53.4 – 66.6)	70.0 (61.0 – 79.0)	44.4 (34.2 – 54.7)
3	**47.6** (43.6 – 51.7)	48.4 (41.3 – 55.5)	50.0 (43.2 – 56.8)	48.0 (38.2 – 57.8)	40.0 (29.9 – 50.1)
4	**42.2** (38.2 – 46.2)	48.4 (41.3 – 55.5)	41.4 (34.8 – 48.1)	49.0 (39.2 – 58.8)	23.3 (14.6 – 32.1)
5	**50.0** (46.0 – 54.0)	55.8 (48.7 – 62.9)	53.3 (46.6 – 60.1)	42.0 (32.3 – 51.7)	38.9 (28.8 – 49.0)
Specificity [b], % (95% CI)					
1	**92.2** (91.1 – 93.2)	94.7 (93.1 – 96.3)	92.3 (90.5 – 94.1)	92.5 (89.9 – 95.1)	86.1 (82.5 – 89.7)
2	**86.9** (85.5 – 88.2)	88.2 (85.9 – 90.5)	86.2 (83.9 – 88.5)	87.8 (84.5 – 91.0)	84.7 (81.0 – 88.4)
3	**83.1** (81.5 – 84.6)	82.0 (79.2 – 84.7)	83.6 (81.1 – 86.1)	87.0 (83.7 – 90.3)	79.7 (75.6 – 83.9)
4	**84.2** (82.8 – 85.7)	82.6 (79.9 – 85.3)	86.0 (83.6 – 88.3)	81.8 (78.0 – 85.5)	86.4 (82.8 – 89.9)
5	**96.6** (95.9 – 97.3)	96.8 (95.6 – 98.1)	96.0 (94.6 – 97.3)	97.3 (95.6 – 98.9)	96.9 (95.2 – 98.7)
Accuracy, % (95% CI)					
1	**88.7** (87.5 – 89.8)	90.1 (88.2 – 92.0)	87.9 (85.9 – 89.9)	89.2 (86.5 – 91.9)	86.7 (83.5 – 89.8)
2	**80.9** (79.5 – 82.3)	81.2 (78.7 – 83.6)	81.0 (98.6 – 83.3)	84.2 (81.0 – 87.4)	76.7 (72.8 – 80.6)
3	**76.0** (74.4 – 77.5)	75.3 (72.5 – 78.0)	76.9 (74.3 – 79.4)	79.2 (75.5 – 82.8)	71.8 (67.6 – 75.9)
4	**75.8** (74.3 – 77.4)	75.8 (73.1 – 78.5)	77.0 (74.5 – 79.6)	75.2 (71.4 – 79.0)	73.8 (69.7 – 77.8)
5	**87.3** (86.1 – 88.5)	88.6 (86.6 – 90.7)	87.4 (85.4 – 89.4)	86.2 (83.2 – 89.2)	85.3 (82.1 – 88.6)

CI, confidence interval; a, vignettes triaged correctly by the raters amongst all the true vignettes as determined by the experts; b, vignettes triaged correctly by the raters amongst all the untrue vignettes as determined by the experts;

Table 5.13 Diagnostic odds ratio, over- and under-triage proportions

Triage Category	Overall	Welcare hospital	City hospital	Al Sufouh clinic	Ibn Battuta clinic
Diagnostic odds ratio, (95% CI)					
1	**34.8** (33.6 – 36.0)	45.3 (42.5 – 48.2)	28.7 (27.0 – 30.4)	39.1 (35.7 – 42.4)	49.6 (45.1 – 54.1)
2	**8.8** (8.5 – 9.1)	8.4 (7.9 – 9.0)	9.4 (8.8 – 9.9)	16.7 (15.3 – 18.1)	4.4 (4.1 – 4.8)
3	**4.5** (4.3 – 4.6)	4.3 (4.0 – 4.5)	5.1 (4.8 – 5.4)	6.2 (5.7 – 6.7)	2.6 (2.4 – 2.8)
4	**3.9** (3.8 – 4.0)	4.5 (4.2 – 4.7)	4.3 (4.1 – 4.6)	4.3 (4.0 – 4.6)	1.9 (1.8 – 2.1)
5	**28.5** (27.5 – 29.5)	38.7 (36.3 – 41.1)	27.1 (25.5 – 28.7)	25.6 (23.4 – 27.8)	20.2 (18.4 – 22.0)
Over-triage [a], % (95% CI)					
2	**26.1** (22.6 – 29.6)	17.4 (14.3 – 20.5)	28.1 (24.5 – 31.7)	24.0 (20.6 – 27.4)	42.2 (38.2 – 46.2)
3	**27.1** (23.5 – 30.7)	19.5 (16.3 – 22.7)	28.6 (25.0 – 32.2)	27.0 (23.4 – 30.6)	40.0 (36.0 – 44.0)
4	**47.3** (43.3 – 13.0)	41.1 (37.1 – 45.1)	45.7 (41.7 – 49.7)	46.0 (42.0 – 50.0)	65.6 (61.8 – 69.4)
5	**50.0** (46.0 – 54.0)	44.2 (40.2 – 48.2)	46.7 (42.7 – 50.7)	58.0 (54.0 – 62.0)	61.1 (57.2 – 65.0)
Under-triage [b], % (95% CI)					
1	**25.3** (21.8 – 28.8)	28.4 (24.8 – 32.0)	29.0 (25.3 – 32.7)	24.0 (20.6 – 27.4)	11.1 (8.6 – 13.6)
2	**16.8** (13.8 – 19.8)	29.5 (25.8 – 33.2)	11.9 (9.3 – 14.5)	6.0 (4.1 – 7.9)	13.3 (10.6 – 16.0)
3	**25.3** (21.8 – 28.8)	32.1 (28.3 – 35.9)	21.4 (18.1 – 24.7)	25.0 (21.5 – 28.5)	20.0 (16.8 – 23.2)
4	**10.5** (8.0 – 13.0)	10.5 (8.0 – 13.0)	12.9 (10.2 – 15.6)	5.0 (3.2 – 6.8)	11.1 (8.6 – 13.6)

CI, confidence interval; a, vignettes that received a higher triage category allocation from the raters as compared to that as determined by the experts; b, vignettes that received a lower triage category allocation from the raters as compared to that as determined by the experts;

5.4.5 Agreement and association indicators

The agreement and association indicators that were found relevant to describe the reliability of the existing triage systems were between the raters and the reference standard (i.e. vignettes), between the raters (i.e. inter-rater), and the correlation between the raters and their triage category allocations (i.e. inter-class) (Table 5.14). The overall agreement between the raters and the reference standard per triage category was substantial for allocations in category one, moderate for those in categories two and five, and fair for those in categories three and four. This agreement between the raters and the reference standard was consistent throughout all four ECs, except for Ibn Battuta clinic which showed substantially less agreement of allocations in categories two, three and four as compared to the other ECs. The overall agreement between the raters and the reference standard for all the triage categories showed an unweighted estimation of moderate agreement, a linear weighted estimation of substantial agreement and a quadratically weighted estimation of almost perfect agreement. The overall inter-rater agreement as estimated through Fleiss Kappa showed only fair agreement between the participants and this was consistent throughout all four ECs. The inter-class correlation was consistent throughout all four ECs showing substantial association between the raters on their triage category allocations.

Table 5.14 Agreement and association between the raters and the reference standard (i.e. vignettes), inter-rater and inter-class

Triage Category	Overall	Welcare hospital	City hospital	Al Sufouh clinic	Ibn Battuta clinic
Agreement between the raters and the reference standard per triage category (Cohen's Kappa), (95% CI)					
1	**0.65** (0.62 – 0.69)	0.68 (0.62 – 0.74)	0.63 (0.57 – 0.68)	0.67 (0.59 – 0.75)	0.64 (0.56 – 0.73)
2	**0.42** (0.38 – 0.46)	0.41 (0.34 – 0.48)	0.44 (0.37 – 0.50)	0.54 (0.45 – 0.63)	0.29 (0.18 – 0.39)
3	**0.29** (0.25 – 0.33)	0.28 (0.21 – 0.35)	0.32 (0.25 – 0.38)	0.35 (0.25 – 0.45)	0.18 (0.08 – 0.29)
4	**0.26** (0.22 – 0.30)	0.29 (0.22 – 0.36)	0.28 (0.21 – 0.35)	0.28 (0.19 – 0.38)	0.11 (0.00 – 0.21)
5	**0.54** (0.50 – 0.58)	0.60 (0.53 – 0.67)	0.56 (0.49 – 0. 62)	0.48 (0.37 – 0.58)	0.44 (0.32 – 0.55)
Agreement between the raters and the reference standard for all triage categories (Cohen's Kappa), (95% CI)					
Unweighted	**0.43** (0.41 – 0.45)	0.44 (0.40 – 0.48)	0.44 (0.40 – 0.48)	0.46 (0.41 – 0.52)	0.34 (0.28 – 0.40)
Linear	**0.67** (0.65 – 0.68)	0.68 (0.65 – 0.71)	0.68 (0.66 – 0.71)	0.69 (0.65 – 0.72)	0.58 (0.53 – 0.62)
Quadratic	**0.83** (0.81 – 0.84)	0.84 (0.82 – 0.86)	0.84 (0.83 – 0.86)	0.84 (0.81 – 0.87)	0.75 (0.71 – 0.79)
Agreement between the raters (Fleiss Kappa), (95% CI)					
Inter-rater	**0.35** (0.34 – 0.35)	0.38 (0.37 – 0.39)	0.38 (0.37 – 0.39)	0.39 (0.37 – 0.41)	0.29 (0.26 – 0.31)
Associative correlation between the raters, (95% CI)					
Inter-class	**0.77** (0.70 – 0.84)	0.80 (0.73 – 0.86)	0.80 (0.73 – 0.86)	0.79 (0.71 – 0.86)	0.68 (0.55 – 0.79)

CI, confidence interval

5.5 Discussion

There was no universal triage system in use among the four Mediclinic Middle East ECs (Table 5.9). The most commonly used triage system within Welcare hospital, Al Sufouh clinic and Ibn Battuta clinic was the Canadian Triage and Acuity Scale, with City hospital reporting that the Manchester Triage System was used the most. Ibn Battuta clinic further indicated that they used the Emergency Severity Index as a supplemental triage system. Understanding which triage systems were primarily used at the four ECs made it possible to not only compare the overall performances of the ECs but also to inter-compare the performances of the triage systems being used. The most reliable comparison can likely be drawn between the two hospitals as these two ECs saw roughly the same patient demographics (Chapter 4). But, retrospective allocations of triage categories from chapter 4 by City hospital did not correlate with that of the other ECs, possibly due to this being the only EC that used the Manchester Triage System. Despite this variation found in chapter 4, the study presented in this chapter found that the performance indicators between the two hospitals had no significant variation. Since the data from chapter 4 were of actual presentations that were different between the ECs and this study had the same simulated triage cases (i.e. vignettes), an inference can be drawn to suggest that the patient population variability between the ECs does influence the interpretation of the findings.

Overall, the sensitivity (i.e. triage rule out) was moderate, with the exception of vignettes in triage category one which received a good performance rating across all four ECs (Table 5.12). This suggests that the triage systems were well applied to determine the highest acuity category, however, there seems to be room for improvement in the sensitivity performance of the other categories. The overall specificity (i.e. triage rule in) was found to be very good. Across the four ECs, there were confidence that inclusion and possible over-triage were more predominant than exclusion and possible under-triage. The diagnostic odds ratio showed that the triage systems do discriminate correctly between triage categories, especially with vignettes in triage categories one and five. This means that the current triage systems

are most effective at the borders of the triage systems' acuity levels (i.e. highest or lowest). It may be that the highest and lowest acuities are the easiest to recognise and would seldom be positively identified and therefore untrue. Reliability and validity studies on the Canadian Triage and Acuity Scale, the Manchester Triage System and the Emergency Severity Index have shown similar findings and variations between these systems, using both vignettes as well as actual patient triage evaluations.(18,24,55,62,69,77,80,117)

The accuracy across all four ECs was consistently good to very good. This is further evidenced in the distribution of triage category allocations (Tables 5.10, 5.11 and 5.13). The triage allocations are tightly clustered around the reference standard and even though there were high proportions of over- and under-triage, the variation was only one acuity level up or down. The American College of Surgeons Committee on Trauma (ACSCOT) would consider this high over-triage rate unavoidable, however, the high under-triage rate (Table 5.13) does exceed their accepted safety limits. A high under-triage rate, however, is cause for concern as this may result in higher acuity patients receiving lower triage category allocations which may lead to unacceptable, increased times to physician and treatment.(62) This concern is evident when looking at the number of cases that should have received a category one triage allocation and therefore deemed critically ill versus those that received a lower allocation (25.3%). With the four ECs mostly seeing lower acuity cases (Chapter 4), it is suspected that the increased under-triage rate may be due to the triage nurses not seeing a lot of high acuity cases, thus creating a bias towards allocating low acuity categories over time. It is also acknowledged that real life cases with visual cues may result in higher category allocations than simply allocating a category from a vignette.(17,63) The over-triage rate increased from high acuity to low acuity categories showing that over-triage was more predominant in the lower acuity vignettes. With over-triage being the safer option, this however, brings an increased demand on resources. Ideally, all patients would be seen and treated immediately by a physician should there be unlimited recourses. Over-triage should be monitored and reduced where possible to keep a balance and avoid exceeding the available recourses. It is however concerning that a high rate of under-triage, coupled with a high rate of over-

triage, as well as the sensitivity and specificity findings, may lead to lower acuity patients being attended to before higher acuity patients. This is far from an ideal situation in emergency care.

The agreement between the raters and the reference standard per triage category at all four ECs followed the same pattern as the sensitivity findings; they suggest that the participants were equally confident in their triage decisions when excluding cases from certain triage categories (Table 5.14). Category one vignettes received substantial agreement, however, the other categories only managed fair to moderate agreement with the reference standard. When all the triage categories were put together without any weights applied to the different acuity levels the agreement between the raters and the reference standard remained moderate. When weights were applied to the acuity levels, either linearly or quadratically (e.g. category one vignettes deemed more important than category five), the agreements rose significantly to substantial and almost perfect agreement; very similar to other studies.(23,24,26,40,42,74,99,110,111,210) This shows that as the acuity levels increased, the agreement between both the participants as well as the reference standard also increased. This is further substantiated by the previously described performance indicators and indicates that the existing triage systems are more focused on identifying higher acuity than lower acuity. Although it is important to identify high acuity cases quickly, a triage system should also remain focused on the majority of the patient population. The patient population described in chapter 4 showed that this type of discrimination should not only be able to identify high acuity cases, but also favour the low acuity environment found in the four ECs. The participant inter-rater agreement was only able to provide a fair performance throughout all four ECs and the associated correlation remained similar between the ECs. This shows that it did not matter which triage system was being applied; they all performed similar in the Mediclinic Middle East EC environment. With the existing triage systems performing similarly and favouring higher acuity cases it appears evident that none of these triage systems are likely to be a good fit for the lower acuity Mediclinic Middle East EC environment.

The majority of participants were between the ages of 25 and 40 which is also reflective of the workforce population as described in chapter 4. The overwhelming majority of EC staff were female. Within the United Arab Emirates, it is a common local health regulation, and an anecdotal preference, to have female nursing staff due to cultural and religious beliefs which makes interaction with female patients easier. The majority of nursing staff come from the Philippines and India, which is also reflective of the majority of expatriate United Arab Emirates workforce. With the majority of Filipino and Indian nurses conducting triage, their fluency in the English language as well as their training and triage experience may indirectly affect the efficacy of a triage system. Current licensure as a registered nurse in the United Arab Emirates follows local regulation and requires a minimum of a Bachelor's degree.(8–10) In cases more than five years ago during the development of the United Arab Emirates, health system nursing Diplomas were also accepted depending on the nationality, origin and evaluation of the qualification. Similar to the qualification requirements of licensure as a registered nurse within the United Arab Emirates, the regulations further required a minimum of two years post-qualification experience for licensure eligibility in the United Arab Emirates.(8–10) Although the overall healthcare experience level in terms of years was very high, the experience within Mediclinic Middle East ECs and triage experience is mainly between two and ten years.

5.5.1 Limitations

Constructing appropriate and unbiased vignettes was the biggest limitation to this study. There have been no previous studies done to compare triage systems with the aid of vignettes in this particular environment, thus new vignettes had to be constructed. The training manuals of the existing triage systems provided some guidance as to the content of the vignettes. It was accepted that triaging written vignettes was very different than triaging a real patient in person. With this in mind, vignettes do provide the benefit of experimental conditions when evaluating the application of a triage system against an objective set of variables, thus somewhat reducing subjectivity. Validation of the vignettes was also limited to a local Mediclinic

Middle East expert panel that reviewed each of the vignettes. There may be some bias applied to the vignettes based on expert experience and opinion, however, there was no fixed standard available for the construction of such vignettes and thus to mitigate potential bias, the experts applied the existing triage systems as a guide to their review. This study was greatly dependent on the participation of the Mediclinic Middle East EC nursing staff. It was hypothesized that Mediclinic Middle East would need to assist in the research endeavours by allowing participants to conduct the survey within working hours. Although time constraints were real, EC unit managers greatly assisted by scheduling enough time during participants' normal working hours to complete the survey. It was anticipated that some staff members would be on leave which would prevent them from participating within the two-week period. With this concern in mind, there was exceptional participation from the available population. This potential bias and the effects thereof were explained to the participants before completion of the survey and it was reported by the unit managers after the closing of data collection that the participants were able to strictly adhere to the research protocol.

5.6 Chapter summary

This study was able to construct a locally appropriate reference standard against which triage system performance could be evaluation. This study has shown that the application of the existing triage systems has proven most effective in allocating higher acuity triage categories, especially to category one cases. The existing triage systems have shown to have middling reliability and validity performance when compared to a bespoke reference standard. The systems perform similarly when evaluated against a reference standard, however, the variations found between the four Mediclinic Middle East ECs require further investigation and understanding. The systems also focus on the identification of higher acuity cases and perform poorly in discriminating between lower acuities, perhaps less ideal in a setting where lower acuities are highly prevalent.

Chapter 6

6 A novel triage system for Mediclinic Middle East

Chapters 4 and 5 considered the planning and analysis steps of the Systems Development Life Cycle. They provided data about the four Mediclinic Middle East emergency centres' (ECs') patient demographics, as well as the reliability and validity performances of the existing triage systems at and between each facility. The findings from these chapters were originally intended to show which of the triage systems would be best suited for the Mediclinic Middle East EC environment, instead it revealed the need for a single, standardised, locally relevant triage system that can be universally used within all four ECs. Chapter 6 considers further planning and analysis steps as well as the first design step by establishing and standardising a novel, best-fit triage system for local use. This was done through action research.

The data collected from chapters 4 and 5 were objective and based on patient medical records and the triaging of written vignettes. Chapter 6, on the other hand, will present subjective findings that describes the perceptions, opinions and experiences of the Mediclinic Middle East EC staff that are involved with the triage process. These subjective findings were used to augment, explain and provide a local context to some of the findings made in the previous two chapters in order to derive the novel triage system described at the end of this chapter. The process started in this chapter is continued throughout the rest of the thesis, permitting reflection on, and modifications to the novel triage system.

6.1 Aim

The aim of this part of the thesis was to determine the most appropriate validation criteria for a local triage system in order to derive the first version of a locally appropriate triage system for Mediclinic Middle East EC, using action research.

6.2 Objectives

1. To derive validation criteria for a novel, standardised, triage system that provides a best-fit for the local environment.

2. To derive an initial version of a triage system for use at the four ECs through the findings from an initial action research process and the findings from chapters 4 and 5.

6.3 Methods

6.3.1 Study Design

This thesis and the overall research project followed an iterative approach as guided through action research on the planning, analysis and design steps of the Systems Development Life Cycle. This chapter continued the trajectory from the previous chapters with the inclusion of the design step (Figure 3.3, Chapter 3). To design a novel triage system for Mediclinic Middle East EC, the fundamental aspects of action research, as described in chapter 3, required the active participation of stakeholders in a mutual collaboration with the researcher.(170,177,178) This was achieved through meetings with the operational staff members and ongoing facilitation with the triage advisory committee throughout the project.

The initial step was to involve the operational staff at the four ECs to establish their experiences with triage within their unit. These staff members were the active stakeholders in the triage process (i.e. they were the providers) and furnished valuable information on the day-to-day interactions they had with the existing triage systems. Interacting with these operational staff members provided valuable insight from a triage provider's perspective and allowed for underlying information to be highlighted that would not necessarily have been realised by the quantitative methods utilised in chapters 4 and 5. This information provided the basis for the validation criteria derived later on.

The initial step, operational staff engagement, was followed by the involvement and establishment of a Mediclinic Middle East triage advisory committee. This committee consisted of the strategic stakeholders necessary to contextually interpret the analysis, make active decisions, and ensure the forward motion of this project. Stakeholder meetings were chosen above consensus based methods due to the interactive nature of action research as well as the business implications that mandated close overview by Mediclinic Middle East management. The latter step was a condition of the study approval from Mediclinic Middle East senior management that required a novel approach to triage system design. Interest and participation were encouraging, leading to several stakeholder meetings with the advisory committee where the novel triage system was presented and later on refined. The first three stakeholder meetings are presented in this chapter as it pertains to the first iteration of the planning, analysis and design cycle. Three additional stakeholder meetings were held during the second and third iterations of the project cycle. These additional meetings were directly advised by the further studies described in chapters 7 and 8. The subsequent stakeholder meeting proceedings are presented in chapters 7.A and 8.A in order to maintain the sequence of events.

6.3.2 Population, setting and size

6.3.2.1 *Operational staff meetings*

For the initial stakeholder meetings, all registered nurses who performed triage within any of the four ECs were invited to participate. There were 69 eligible nurses; their backgrounds and demographic data have previously been described in chapter 5. The same 69 registered nurses that were invited to participate in chapter 5's study were invited to participate in the stakeholder meetings. Several formal meetings were conducted at the various ECs during the participants' working hours, however, they did not affect service delivery within the ECs.

6.3.2.2 *Triage advisory committee*

Subsequently, there were more formal meetings held with the triage advisory committee. These meetings were conducted during the participants' working hours at times that would not affect service delivery within the organisation. This committee consisted of Mediclinic Middle Easts' chief clinical officer, the four facility medical directors, the two medical heads for the hospital ECs, the four EC unit managers and the clinical education manager. These committee members were purposefully chosen in conjunction with Mediclinic Middle East management. The participants were chosen because they were not only knowledgeable about the clinical implications of triage, but also because they were stakeholders within the organisation and were trusted to make business decisions about triage. The participants are all well experienced within healthcare and in their respective fields. Most of the participants hold postgraduate academic and research degrees. They understood the research domain and were able to provide insightful comment during the process. This further strengthened Mediclinic Middle Easts' involvement, which made this project part of their business objectives.

The chief clinical officer and facility medical directors were included because their senior managerial positions within Mediclinic Middle East, their expertise in operational management, and because they were specialist medical doctors they were able to impart valuable clinical knowledge and experience. The medical directors for the two clinics were also the EC heads by virtue of their position within the organisation, however, the two hospitals ECs have separate medical heads and they were included for the same reasons as the medical directors. The medical heads for the ECs were also able to impart their knowledge and experience of the triage process within their ECs. The unit managers all had nursing backgrounds and were able to impart their knowledge and experience of the triage process and the triage systems used within their ECs. The unit managers were also able to describe the triage process from a triage nurse perspective, bringing insight to the operational application of triage. The clinical education department within Mediclinic Middle East is instrumental in the development, implementation and maintenance of clinical

policies, practises and training within the organisation. The clinical education manager, who also came from a nursing background, was included to provide and impart knowledge and experience to the benefit of the project.

6.3.3 Data collection

6.3.3.1 *Operational staff meetings*

The first step was the organisation of the stakeholder meetings held with the operational nursing staff. This was arranged through the unit managers at each EC. As the researcher was not well known by the participants, it was felt and agreed to by the unit managers that the participants would be more open to sharing information with a colleague they trusted and worked with, rather than someone they were unfamiliar with. This approach allowed participants to respond without pressure and ensured a comfortable environment to share information. This had the additional benefit of providing an element of blinding to responders as the researcher was not directly involved in the meetings. The format thus allowed for an open, safe platform for the participants to express their opinions.

To enable this format of meetings, unit managers approached staff they thought were suitable to act as volunteer, research assistants to lead the discussions. Potential volunteers were approached on different shifts, informed of the study and asked if they'd be willing to volunteer for this data collection task. All potential volunteers agreed to their roles, and are referred to as research assistants for the duration of this and all other studies. The researcher then individually met with each of the research assistants for an educational briefing. During the briefing, the research assistants were given a set of semi-structured questions, reflective of the study's core issues, that were used as a script to lead a closed discussion (Box 6.1). These questions were derived from discussions had with the unit managers. Having several key questions in place helped define the areas of exploration, but also allowed the participants to expand their input a little more freely.(131)

Research assistants were given a two-week period (from 1 to 14 May 2015) to meet with the participants within their units and collect the required data. They were instructed to take observational field notes as they spoke to the participants and use the questions as a script for their interaction. Research assistants were also allowed to give their input as imbedded participants within the groups. It was requested that they collect and compile the discussion and inputs from participants for review by the researcher. The contact details of the researcher were made available to all the participants should they have queries or want to give their inputs directly. None of the participants contacted the researcher directly.

Box 6.1 Semi-structured questions addressing the study's core issues

1. What is the triage system used in this emergency centre?
2. How much experience does the participant(s) have with this or any other triage system?
3. What is the participant(s) opinion on the current triage system being used in their emergency centre with regards to:
    - usability,
    - efficiency,
    - reliability and
    - validity?
4. What are the perceived:
    - pros and
    - pons of that utilised system and
    - why?
5. What are the obstacles to effective triage within their emergency centre?
6. How can it be improved?
7. What is the participant(s) view on a standardised triage system for all Mediclinic Middle East emergency centres?

Meetings in groups of between one and five operational nursing staff members were held between 1 and 14 May 2015. This format allowed for flexible meetings to be held at times that would not affect service delivery, often a challenge within the EC environment. In the end, there were a total of 66 participants: 21 from Welcare hospital, 25 from City hospital, ten from Al Sufouh clinic, and ten from Ibn Battuta clinic. Operational pressures resulted in a few instances where research assistants collected data from just one participant at a time. In the majority of cases, however, group sizes were larger. All research assistants indicated that they felt strongly that the data collected represented the ideas and views expressed by the participants.

6.3.3.2 *Triage advisory committee*

Following the initial stakeholder meetings with the operational nursing staff, the triage advisory committee was established as described earlier. The researcher facilitated the five one- to two-hour stakeholder meetings by acting as chair of the triage advisory committee. Data was captured by taking minutes and affirming the content thereof with participants at the end of each meeting. A research diary was kept to keep track of all the minutes, research elements and decisions made through this action research process. The meetings were run as a closed forum with the researcher starting the meetings with a set purpose and objectives that had to be achieved by the end of the meeting. Discussions were directed by the facilitator to achieve the objectives of each meeting. The committee was managed as a group with the outcomes of each meeting being decided upon through informal democratic agreement. Each meeting started off with a brief recap of where the project was in the action research process, what had been done so far and what was required at that specific meeting. The results of the data captured prior to each meeting were presented to the committee for further interpretation and reflection. Further discussion of ideas and concepts ensued (described later) throughout the meetings, culminating in decisions taken and further action points to be reviewed at the next meeting. The triage advisory committee meetings served as beacon points throughout the action research process indicating the end of an iteration cycle and the start of a new one.

This chapter presents the data collected from the first three triage advisory committee meetings. Additional triage advisory committee meetings are presented in chapters 7.A and 8.A in order to maintain the flow of the research timeline. The overall objectives of the meetings presented here were to evaluate the data from chapters four and five, decide what triage system would be best suited and initiate actions for the design and further development process. The first triage advisory meeting was held on 3 June 2015 with six members. This was used as a scoping meeting. It was recognised at this meeting that not all the required committee members could attend all the meetings due to organisational requirements. It was agreed that for the meetings to be of value, that each meeting should consist of at least two medical directors, two EC medical heads and two EC unit managers. The second meeting was held on 29 of June 2015 with eight members, and the third meeting was subsequently held on 22 July 2015 with six members. Although not all the committee members could attend every meeting, each member attended at least one of the initial three meetings. The meeting minutes were shared with all the committee members to give everyone an opportunity for input on the outcomes of the meetings. There were no disagreements noted from non-attendees.

6.3.4 Data analysis

A simplistic description of the difference between quantitative and qualitative data is that the former deals predominantly with numbers and the latter with words.(134) In the analysis of quantitative data, a mass of numbers is summarised, described and analysed, usually through statistical measures.(134) When analysing qualitative data, a mass of words are generated through interviews or observations which also need to be described and summarised.(134) Analysing qualitative data is usually not a distinct step as in quantitative analysis where all the data is captured and then analysed. Qualitative data analyses can often be done concurrently with data collection. The purpose of this qualitative analysis approach is to reflect on the meanings and relationships that exist within the data.(130) This type of analysis is usually interpretative and subjective, requiring the researcher to be intimately involved in the process.(134)

The most common form of analysing and understanding qualitative data is through the creation of themes.(130,134,203–205,211) Themes are patterns that emerge from the data to describe a concept. This method of searching for themes out of a dataset is called thematic analysis. The term thematic analysis can be loosely coined in any circumstance where themes are created from data, however, in research methodology, this term often reflects a procedure of generating themes. This procedure uses a method called coding to apply numerical or textual values to identify specific pieces of data which correspond to differing themes.(134) Coding can be done manually on paper or entered into computer software that is specially designed to help filter and manage the qualitative data.(130) In simple terms, coding is the marking of relevant points within the data. When reviewing the data, these codes can be allocated to represent similar concepts and then brought together at a later stage as one theme.(205) The purpose of this approach is to reduce large amounts of data into manageable portions by combining and summarising similar concepts, and then repeating the process multiple times.(205) This process can be intensive as all the data needs to be evaluated by the researcher.(205) This brings about possible limitations as the researcher may subjectively overlook crucial concepts within the data. The customary steps in this form of analysis are: becoming familiar with the data by reading it multiple times, generating codes, identification of themes, re-coding, refining themes, exploring the relationships between themes, developing theories, and lastly writing the report.(134) The report is usually a narrative discussion around the themes that gives meaning and understanding to them.(134,203,204)

When analysing for themes through thematic analysis, there is often the risk of either under- or over-analysis.(204) This simply means that either too many themes are created with little significance or there are too few themes and crucial concepts are lost by combining too many themes. To avoid either of these problems, a method of visual thematic networking can be used. Thematic networking is creating a visual mind-map, a process of stratifying themes into either basic, organising or global structures (Figure 6.1).(204) Basic themes are the foundational blocks that are derived from the data (i.e. usually the first round of theme identification during

thematic analysis), these basic themes are then grouped together under an organising theme (i.e. usually the second round of theme identification during thematic analysis), and lastly, the global theme is established as the predominant theme from the data (i.e. usually the theory created during thematic analysis).(204) This can be expanded further, where each global network can also have multiple stratosphere groupings, for example. (204)

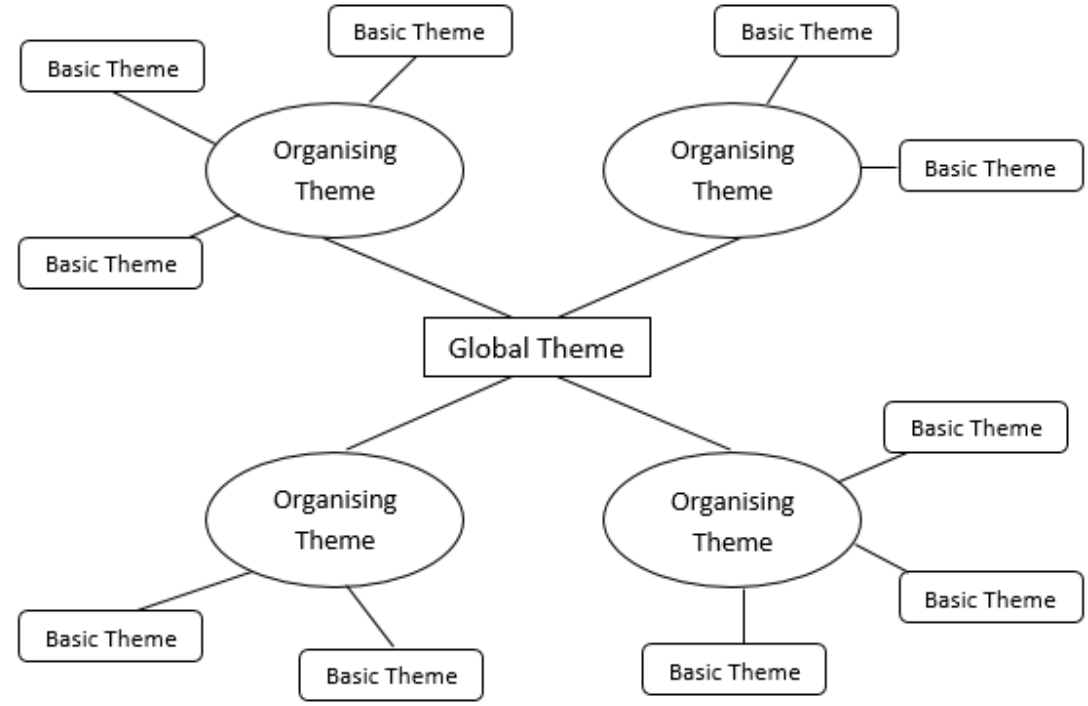


Figure 6.1 Structure of thematic analysis (adopted from Attride-Striling 2011) (204)

6.3.4.1 *Operational staff meetings*

A thematic analysis and networking approach was used during the analysis of the initial stakeholder meetings with the operational nursing staff (Box 6.2). This method was modified to suit the scope of this study as the core issues were identified prior to the meetings taking place. By following the scripted semi-structured questions, the participants were able to give directed answers toward the pre-determined index. In traditional thematic analysis, the original participant input data was captured and then transcribed to reflect their individual inputs. This was modified to

allow the research assistants to collect observational field notes and meant that the research assistants provided a summary of the overall participant inputs at each EC, which in turn identified the first group of basic themes. The goal of this study was not to compare the inputs and themes between the four ECs, but to generate a collective view. The data was coded under the following six organising headings: characteristics of the existing triage systems, staff involvement in triage, hospital versus clinic triage, patient interaction with triage, educating staff about triage, and improvement possibilities for triage. The findings are reported as a narrative discussion under each heading, with a theme summary at the beginning.

Box 6.2 Modified thematic analysis process, qualitative study (134)

Research assistants

- Transcription and summarisation of observational field notes
- Informal identification of themes
- Organising and indexing the data under the semi-structured questions

Researcher

- Familiarisation with the data
- Organising all the data from the four emergence centres under a single index
- Initial coding with textual headings
- Formal identification of themes
- Establishing thematic relationship to study core issues
- Refining of themes into basic and organising structures
- Narrative report with theme summary

6.3.4.2 *Triage advisory committee*

Analysis occurred during each triage advisory committee meeting as the discussions progressed and democratic agreement was reached on certain decisions. The researcher, as chair of these meetings, was able to observe and guide the discussions to meet the objectives of each meeting. During this time, the researcher picked up

on recurring themes during the discussion and posed these themes to the committee. Through committee consensus, these themes were documented in the meeting minutes as outcomes and action points. While following the action research process, the committee meetings were thus self-analysing and the findings reported are a direct reflection of the meeting's minutes. The meeting's findings are reported by presenting the purpose, main outcomes, and action points of each meeting.

6.4 Results

6.4.1 Initial stakeholder meetings with operational nursing staff

6.4.1.1 Theme summary

The initial stakeholder meetings with the operational nursing staff provided major insight to triage from their perspective. This was an extensive undertaking to highlight key concepts that could be taken to the triage advisory committee. These concepts are important in the development of a novel triage system as these are the staff that will use the end product. The themes presented are all at the organising level which were aggregated from the basic themes agreed upon by most or all of the participants from the four ECs. There were six coded headings identified as global themes each with their own organising themes (Box 6.3).

Box 6.3 Initial stakeholder meeting global and organising theme summary

Characteristics of the existing triage systems

- They are easy to use and reliable.
- They are not applicable to all the emergency centres.
- Accuracy when applied to children and infants is a concern.

Staff involvement in triage

- The degree of involvement varies between emergency centres.
- The staff do not strictly adhere to the system used.
- Doctors and nurses have a different view on triage category allocations.

Hospital versus clinic triage

- The hospitals see both higher volumes and acuities of patients than the clinics.
- Patient volumes and time of day affect patient flow within the hospitals.
- The clinics have resource constraints that impact their triage.

Patient interaction with triage

- There is miscommunication between staff and patients.
- Patients do not understand the triage process and categories.
- There is no post-triage interaction with the patients.

Educating staff about triage

- The triage training given is not enough.
- Training should be on the system implemented at the emergency centres.
- Ongoing education and training is essential.

Improvement possibilities for triage

- There is strong support for a standardised triage system.
- Triage should be simplified to be quick and efficient.
- Review, auditing and validation systems should be in place.

6.4.1.2 Characteristics of the existing triage systems

The participants indicated that the most used system throughout the four ECs was the Canadian Triage and Acuity Scale, with only one EC using the Manchester Triage System as its primary triage system. Participants from all four ECs acknowledged that they conformed to a single triage system most of the time, but that they did use others systems like the Emergency Severity Index and previously the South African Triage Scale as adjuncts; the degree to which these adjuncts were used could not be delineated. Participants did offer some explanation as to why the Canadian Triage and Acuity Scale was the predominant system in use and why different triage systems were implemented across the four ECs. The following extracts were taken from the research assistant field notes.

> *"The staff have the capability to use this system for it has been their practise in other hospitals that they previously worked."*

"There is no specific reason why these systems were implemented except for the personal preference of the implementing managers."

It was commented at all the meetings that the Canadian Triage and Acuity Scale was also the primary triage system that the participants were exposed to during triage training sessions.

"Since staff started for years in this institution they had been trained to use the system and being educated on this and trained for continuous education."

Participants from one hospital felt that the Canadian Triage and Acuity Scale was easy to use whilst participants from the other hospital felt that the Manchester Triage System was easy to use. Participants from both hospitals considered their triage systems as reliable.

"The Manchester Triage System with proper use of flow charts and understanding of discriminators is reliable and efficient. It is easy to use but needs proper training and support from members of the EC team."

"It is basic and easy to identify. If a nurse does not make mistakes and she is reliable enough to triage its [Canadian Triage and Acuity Scale] reliable and efficiency is excellent."

Participants from both clinics commented that given their relative lack of resources compared to the hospitals, they used the Emergency Severity Index as an adjunctive triage system for its perceived focus on resource allocation.

"The Emergency Severity Index system was introduced to the clinics as an aid to resource allocation for triaged patients."

Participants were concerned about the accuracy of the triage systems when applied to children and infants, as the overwhelming majority of triage material was perceived to be aimed at adult presentations. The Manchester Triage System was used at only one EC, namely City hospital. Meeting participants perceived the system

to be too regimented, with the reference tool being too exhaustive. They felt that relying on memory alone to allocate categories correctly to be potentially harmful in most cases. A similar concern regarding the accuracy of the tool when applied to children and infants was highlighted. Participants from all four ECs commented that they were knowledgeable that the modified early warning score was being phased in for in-patients apparently to track patients' physiological progress and identify deterioration.

6.4.1.3 Staff involvement in triage

Participants commented that their involvement in the triage process varied within the four ECs. There were two systems of rotation that existed, either all the participants were given a turn to triage or only a few selected senior participants were allowed to triage.

> *"In Welcare hospital, Al Sufouh and Ibn Battuta clinics the EC nurse rotates to perform triage duties whereas in City hospital only a small group of nurses are used for triage."*

Participants did not know why this difference existed and could only speculate that it was purely due to the management style of their unit managers. On the one hand, having all the nurses perform triage allowed for a diverse application of staff, whereas on the other hand, having a small group of senior nurses allowed for tighter control. The participants did not agree on which of the two ideologies was the best. It was not surprising that the participants from Welcare hospital, Al Sufouh and Ibn Battuta clinics believed that it would be better for all staff to be involved in triage duties. This was contrasted by the participants from City hospitals who believed that dedicated triage nurses would provide better overall triage, especially for paediatric patients.

> *"We need a specific [person for] dedicated paediatric triage, as well as dedicated triage nurses who will be specialised in this specific skill."*

Participants conceded that they did not strictly adhere to the triage systems within their ECs. The participants explained that there are neither check-ups nor targeted auditing done to verify the accuracy of their triage category allocations. The only times issues were raised was when their allocated triage category was questioned by a doctor. Some of the participants were concerned that this subjectivity could result in triage errors and affect patient safety.

> *"Triage system descriptors are not used sufficiently and accurately causing problems with clinical decision making and much nurse subjectivity." [commenting from personal experience and gut feeling toward the use of descriptors in triage]*

Participants from all four ECs felt that the way the nurses and the doctors perceived the use of triage to be very different. The participants commented that it was often the case that they would be questioned by the doctor on why a patient received a triage category which they believed should have been lower. The participants further mentioned that it was common for doctors to re-triage patients based on their clinical examination, and felt that the triage nurses' category allocations were being unfairly scrutinised as being wrong from the beginning.

> *"Nurse and physician acuity discrepancies are frequent with a perceived over-triage by the nurses."*

> *"Doctors don't even know the triage system being used and then tell the triage nurse that the patient is triaged incorrectly."*

Participants felt that the doctors have been desensitised to the differences in cases for lower acuity categories three, four and five. The participants suspected that it might be due to the high volumes of low acuity cases that visit the ECs.

> *"Some physicians do not understand the differences in category three to five acuity levels due to the vast amount of low acuity patients they see."*

Across all four ECs the participants commented that the hospital information system required too many inputs for triage, which increased patient waiting times and could potentially cause treatment delays.

> *"The time period required for entering the triage notes on the hospital information system is long, which leads to delaying a patient's consultation."*

6.4.1.4 Hospital versus clinic triage

Participants from all four ECs perceived that the patient populations between the hospitals and clinics were different in relation to volume and acuity. Participants from the clinics commented that their patient volumes and acuities are much lower than the hospitals. This is corroborated by the data presented in chapter 4. Participants from the clinics experienced that with the low patient volumes coupled with low acuity presentations and quick access to a physician, the triage process was a cause of delay to treatment. Participants from the hospitals did not feel the same way.

> *"The triage system is very good, but it is not completely applicable for the clinics as we are mostly receiving patients with triage categories of 4 and 5."*

> *"The waiting period will not exceed 30 minutes even for triage category five. The triage systems may be better suited for the large hospital ECs."*

Participants from all four ECs agreed that high acuity cases in categories one and two cases were seen immediately by a physician, however, the time to physician in the hospitals and clinics vary considerably for category three, four and five cases. Participants believed that this is a volume issue as the hospitals see more patients than the clinics. Participants from the hospitals commented that this is also dependant on patient volumes variations during the day.

> *"Even for clients [who are] not acute and the triage category being five, these cases will be seen by a doctor [in the clinics] in less than 10 minutes."*

Participants from the clinics expressed concern that patients were often given a higher triage category purely because of resource constraints within the clinics, therefore, their allocated triage category did not reflect the patient's true acuity level. Participants from the hospitals felt frustrated having received patients referred from the clinics with what they perceived to be incorrectly assigned, higher triage categories; they could not understand why this was the case. The participants surmised that this might be because the ECs used different triage systems with varying triage outcomes.

> "*The triage system must be based on the region and the clients you cater for."*

> *"The clinics may evaluate acuity scores differently because of the resource constraints, thus creating higher acuity scores, an inaccurate true presentation based on the triage system."*

6.4.1.5 Patient interaction with triage

Participants from all four ECs were concerned about the miscommunication they experienced between themselves and the patients. Dubai's large nationality distribution (Chapter 4) and its language diversification was reported as being difficult as there were not always interpreters available. All participants agreed that this could lead to missing crucial information related to patient symptoms and medical history.

> *"Effective communication poses a challenge when patients present to the EC."*

> *"As a patient has the right to have informed consent, explanation of reports and diagnosis, the lack of interpreters can be a risk not only to the patients but to the hospital with medico-legal cases developing due to this problem."*

Participants from all four ECs were also concerned that patients often complained about the triage process, the questions asked and sometimes long waiting periods, as the patients had seen this as a delay in treatment. Participants had often experienced that patients were left in the waiting areas without any follow-up or

information given post-triage, which added to patient stress and the perceived negative connotation with triage.

> *"Patients don't understand the triage category system. Patients don't prefer to wait for a long time and often withhold important information."*

6.4.1.6 Educating staff about triage

Participants from all four ECs were aware that Mediclinic Middle East clinical education department offered a triage course for continued professional development that they could attend annually. Some of the participants felt that more education was needed especially for the triage system implemented in their specific EC.

> *"We only read about other triage system and have not been introduced to it."*

> *"Though we are following the Canadian Triage and Acuity Scale many times we weren't able to follow the triage pattern due to insufficient education."*

Participants from all four ECs agreed that ongoing triage education and training was required due to poor retention of knowledge and skill, especially for those participants not regularly involved in triage. All participants felt that with increased training there would be better flow within the EC as well an increase in the nurses' confidence within their triage roles.

> "*Ongoing education to staff having a difficult time in triage is also important."*

> *"When you have trained triage nurses we will have better EC flow, patient complaints will be lessened and the nurse will feel better [about] job satisfaction."*

6.4.1.7 Improvement possibilities for triage

Some participants were concerned about the medico-legal implications of triage, especially the risk involved when an incorrect triage category was allocated in a

missed high acuity case. For this reason, most of the participants felt that there should be proper review, auditing and triage validation systems in place as an assistive tool to help improve their triage skill and abilities. Participants felt that triage should be quick and efficient, especially in the hospitals where patient volumes were higher. Participants from all four ECs strongly supported the notion of having a single standardised triage system throughout all the ECs.

> "*There needs to be a unified triage system through the whole group."*
>
> *"Standardised triage in our group will be an advantage because if everyone in the group follows the same standards then we ensure continuity of care and quality of care in higher levels."*

6.4.2 Mediclinic Middle East triage advisory committee meetings

6.4.2.1 First triage advisory committee meeting

The first triage advisory committee meeting (Box 6.4) was held on 3 June 2015 and was attended by six committee members. This was the first meeting of the newly established triage advisory committee and followed the studies already conducted in chapters four and five. It was found that the majority of patients seen within the four ECs were low acuity presentations. It was further recognised that the way in which high acuity triage categories (one and two) and low acuity triage categories (four and five) were managed in the ECs were respectively similar. Combining categories one with two and four with five allowed for a three-level triage system to be created.

Box 6.4 First triage advisory committee meeting's minutes

Purpose

- To provide feedback on the research conducted and data gathered in phases one and two [Chapters 4 and 5].
- To establish a strategy and set the direction in which the project was going to go from this point onwards.

Main outcomes

- The committee members are pleased with the research already conducted and the data that was captured.
- The number of Emirati nationals (21.9%) that visit the ECs is contrary to the popular beliefs among the members.
- A request is made to compare the phase two results [Chapter 5] from the four ECs against each other.
- There is concern raised for the high under-triage rate (19.4%).
- Categories one and two (high acuity) patients are well recognised and managed immediately within the units.
- Categories four and five (low acuity) patients are usually seen within recommended timeframes.
- Categories one and two as well as four and five for practical purposes are dealt with similarly within the units and could be grouped together. This indicates that a three-level triage system could be a possibility.
- Consensus is reached based on analysis of the data and committee members' opinion that a three-level triage system should be developed that could be better suited to the Mediclinic Middle East EC environment.
- Concern is raised as to the impact the prospective data capture would have on business operations during the next phase [Chapter 7].
- A recommendation is made to calculate a suitable sample size necessary for further prospective investigations based on the data from phase one [Chapter 4].

Action points

- The next triage advisory committee meeting should be scheduled at the end of June 2015.
- Further data analysis and comparisons should be conducted as requested and presented to the committee.
- A conceptual, three-level triage system should be constructed by the researcher to demonstrate its use. A combination of descriptor and vital parameter point based triage systems such as the South African Triage Scale should be constructed.
- This conceptual system will be presented, evaluated and discussed at the next committee meeting.
- A sample size calculation for the next phase [Chapter 7] should be done by the researcher.

EC, emergency centre; all wording in brackets, e.g. [Chapter 7], has been added for reporting purposes in this thesis

6.4.2.2 Second triage advisory committee meeting

The second triage advisory committee meeting (Box 6.5) was held on 29 June 2015 and was attended by eight committee members. This meeting followed from the first meeting's instruction and delved deeper into the evaluation of the data presented in chapters four and five. There was further exploration and development of a conceptual three-level triage system. There were two aims established to define the goals of triage for Mediclinic Middle East. They were to detect and treat critically ill patients quickly and to improve the flow of patients through the ECs. It was recognised that further data was required to aid in the development of the novel triage system. It was decided that the novel triage system would consist of two sections, an early warning score section where an initial triage allocation could be made using patient vital sign parameters and a clinical descriptor section that determined whether certain clinical conditions (e.g. signs and symptoms) warranted a triage category upgrade to a higher acuity allocation. The early warning score would determine the baseline triage category allocation with clinical descriptors capable of upgrading that allocation.

Box 6.5 Second triage advisory committee meeting's minutes

Purpose

- To present a conceptual three-level triage system that consists of vital parameters and clinical descriptors.
- To further develop the conceptual idea through evaluation and discussion.

Main outcomes

- A brief overview of the discussions and decisions from the first advisory committee meeting is presented.
- The committee is intrigued that the category two triage cases from City hospital are markedly increased as compared to the rest of the ECs as found in phase one [Chapter 4]. The members agree to the initial analysis that the cause may be due to City hospital being the only EC utilising the Manchester Triage System.
- The definition of triage and how it relates for Mediclinic Middle East is debated.

- Two relevant aims are established to define what triage means for Mediclinic Middle East. The first is to detect and treat critically ill patients quickly and the second to improve the flow of patients through the ECs by means of triage.
- The flow of patients is broadly defined are refers to timeframes, treatment regimes, patient streaming, patient experience, movement of patients through the EC, etc.
- The role of triage nurses and the importance of that function is discussed with emphasis on the training, clinical decision making, and the importance of triage nurse authority with a broader impact on resource allocation and unit decision making.
- The committee agrees that the assessment of patients by the triage nurse should be beyond that of a single page triage tool. It is accepted that a complete medical textbook cannot be placed onto a single page and thus the training of triage nurses should focus on the principals of triage rather than the specific system.
- The committee concludes that more data is needed if a holistic approach is to be taken in the development of a novel triage system. The capture of this data should be the next priority within the project.
- The committee realises that there is a lack of data required that was not being captured previously, such as timeframe data (i.e. time to: registration, triage, physician, discharge) and certain vital parameters were also not captured. Focus should also be placed on missing data points which limited phase one [Chapter 4]. During phase four [Chapter 7] focus and effort can be made to capture all the required data.
- The committee believes that a smaller (than phase one) prospective study would solve these issues and data can be captured that would assist in future decision making and triage system refinement. The relatively quiet month of August is selected to conduct this study as the sample size calculations showed that would be sufficient to capture an appropriate data sample to base analysis and decisions on. This sample size calculation was made in conjunction with the Mediclinic South Africa statistical department.

Action points

- The next triage advisory committee meeting should be scheduled before 1 August 2015 when phase four [Chapter 7] would commence.
- The committee requests the researcher to compile a list of early warning scores and clinical descriptors from existing triage systems as basis for the content of the conceptual three-level triage system. This list should be distributed to all the committee members prior to the next meeting for review and comment.
- The researcher should determine what data was required to be captured to satisfy the project needs.

- The researcher should determine what data is available on the hospital information system and what data would require manual capturing.
- A draft of the manual data capture form for phase four should be developed and presented for approval at the next meeting.

EC, emergency centre; all wording in brackets, e.g. [Chapter 7], has been added for reporting purposes in this thesis

6.4.2.3 Third triage advisory committee meeting

The third triage advisory committee meeting (Box 6.6) was held on 29 June 2015 and was attended by six committee members. This was the last meeting before the next phase of the study (Chapter 7) was initiated to capture more data for the novel triage system's development. This was an intensive meeting that reviewed multiple international triage system early warning scores (Appendix F) and clinical descriptors for use in the novel Mediclinic Middle East triage system. Through a process of discussion, debate and ultimate consensus, the relevant early warning scores and clinical descriptors found to be relevant were decided upon for use in the novel triage system. The first version of early warning scores and clinical descriptors were decided upon (Tables 6.1 and 6.2).

Box 6.6 Third triage advisory committee meeting's minutes

Purpose

- To finalise the arrangements for the phase four [Chapter 7] prospective data collection.
- To reach initial consensus on the early warning score values and clinical descriptors that would be use for the novel triage system.

Main outcomes

- The manual data capture form for phase four [Chapter 7] is reviewed and accepted by the committee. It is agreed to combine electronically captured data from the hospital information system with the manually collected data to avoid duplications and operational delays.
- The sample size is again reviewed and approved by the committee.
- An extensive portion of this meeting is spend going through the early warning scores and clinical descriptors that was compiled from various international

triage systems. The committee reviews, evaluates and discusses each section and designs the first version of the early warning scores to be used in the novel Mediclinic Middle East triage system [Table 6.1].

- The committee decided that any patient with a vital sign parameter that attains a three score on the early warning score would receive a category one allocation. For the other early warning score calculations, a score of seven or higher should be a category one, four to six a category two and zero to three a category three.
- The committee decided to keep a wide range of clinical descriptors [Table 6.2] that could be used in the analysis of phase four [Chapter 7] data and that delineation of this descriptor list would occur during the next meeting.

Action points

- The next triage advisory committee meeting should be scheduled after the phase four [Chapter 7] data has been collected a provisionally analysed by the researcher.
- The researcher is responsible to conduct the phase four [Chapter 7] study.
- Meetings should be arranged with the unit managers and the medical records department to help facilitate the study.

EC, emergency centre; all wording in brackets, e.g. [Chapter 7], has been added for reporting purposes in this thesis

Table 6.1 Triage advisory committees' early warning scores for adults and children

Parameter	3	2	1	0	1	2	3
AVPU		New Confusion		Alert	Voice	Pain	Unresponsive
RR (rpm)	≤ 8		9 – 11	12 – 20	21 – 24	25 – 29	≥ 30
SpO_2 (%)	≤ 91%		92 – 93%	≥ 94%			
HR (bpm)	≤ 40		41 – 50	51 – 100	101 – 110	111 – 129	≥ 130
SBP (mmHg)	≤ 70	71 – 80	81 – 100	101 – 199		≥ 200	
Temp (°C)	≤ 35		35.1 – 36	36.1 – 38	38.1 – 39	39.1 – 41.5	≥ 41.5
Pain*				0 – 3	4 – 7		8 – 10

AVPU, alert-voice-pain-unresponsive; RR, respiratory rate; rpm, respirations per minute; SpO_2, oxygen saturation; %, percent oxygen; HR, heart rate; bpm, beats per minute; SBP, systolic blood pressure; mmHg, millimetres of mercury; Temp, temperature; °C, degrees Celsius; *, pain score up to 10 with 10 indicating the most severe

Table 6.2 Triage advisory committee's initial list of clinical descriptors

abdominal pain	joint swelling and pain
allergic reaction – severe	light-headedness
anxiety – severe	obstructed airway
arrest – code/resuscitation	obvious deformity
asthma – severe	pain unresponsive to analgesics
burn – facial or inhalation	palpitations
burn less than 20%	photophobia
burn more than 20%	poisoning/overdose
cardiac – neck, jaw or arm pain	pregnancy and trauma
chemical exposure	pregnancy and vaginal bleeding
chest pain	prolapsed cord
child – looks severely unwell	psychosis – acute
confusion – new onset	pulsatile bleeding
constipation – severe	respiratory distress – mild
dehydration – adult – moderate/severe	respiratory distress – moderate
dehydration – child – moderate/severe	respiratory distress – severe
dialysis problems	restlessness/irritability – severe
dislocation of finger or toe	ruptured membranes
eye injury	seizure – current
fracture – closed	seizure – post ictal
fracture – open	shock – moderate
haemoptysis	shock – severe
haemorrhage – controlled	stroke – acute
haemorrhage – uncontrolled	sudden throat/tongue swelling
head injury with risk features	threatened limb
history of loss of consciousness	trauma – major/severe
hyperglycaemia > 17mmol/l	trauma – moderate
hypoglycaemia < 3mmol/l	uncontrollable itching
infant < 1-year-old	unresponsive
infection – severe	vomiting fresh blood
joint dislocation with vascular compromise	vomiting persistently

6.5 Discussion

Analysing qualitative research usually involves the presentation of findings and concurrent discussion thereof as the process unfolds. The action research model used in this project requires the intimate involvement of the researcher to engage the stakeholders during the process of planning, analysis and design. During the course of this study, discussions become a frequent part of the iterative process toward the development of a novel triage system. It is however important for the researcher to take a step back from time to time and look at the overall picture and evaluate the progress of the research. During this time, a research reflection can be made on how the development process is progressing, how it relates to other studies and to research in the field, and how well it remains in focus of the project's overall aim and objectives. This discussion allows for a dissemination of the qualitative data captured during both the operational staff meetings and the triage advisory committee meetings.

6.5.1 *Operational staff meetings*

The contributions made by the operational nursing staff provided major insight to what a triage system requires for the end user within the Mediclinic Middle East EC environment. The basic themes generated by the research assistants were further analysed by the researcher who was able to extrapolate six global themes, each with three respective main organisational themes. The participants all found the triage systems they were using within their ECs to be easy to use and reliable. This may be due to them having spent extensive time using that particular triage system and not having an operational comparison to judge the ease of use against. It was found in chapter 4 that most of the participants had not been trained in a variety of triage systems so the possibility was that the current triage system they were engaged with was the only triage system they had ever experienced. It was recognised by the participants that these triage systems were not applicable to all the ECs, especially given the patient volume differences between the hospitals and clinics. Anecdotally, the triage systems used in the clinics were believed to cause an actual delay in time to seeing a physician. This assumption was investigated in chapter 7. The accuracy

of the existing triage systems, when applied to children and infants, was also brought into question, however, studies conducted to evaluate this have shown that they are indeed accurate.(69,70,83–86,129,212) This underlying concern highlighted by the participants requires further investigation.

The varied perceptions between physicians and nurses on triage category allocations was of concern and required further investigation. This may be a result of training, experience and expectation differences between the physicians and the nurses. It was also concerning to find that the nursing staff did not strictly adhere to the triage system used in their EC. This may be a result of staff not understanding how to apply the triage systems, a lack of appropriate training and experience, or a failure of the triage system itself as applied to the Mediclinic Middle East EC environment. It may also have been because nurses intuitively realised that the existing triage systems was biased towards higher acuity. Nevertheless, this finding highlighted that appropriate training needs to be carried out before implementing any new triage system, that the triage system needs to be focussed to the qualification level of the nursing staff, and that appropriate auditing systems should be in place to ensure adherence to the triage system. Not only should the triage system be easy to understand by the providing nursing staff, but the system should be transparent and open for patients to understand as well. An objective triage system based on calculable parameters will not only make it easier for nursing staff to triage patients, it will allow them to substantiate their triage category allocations. This may also improve patient confidence as the uncertainty in their subjectivity of their triage category allocation may be reduced. These dynamics of triage system application within the Mediclinic Middle East EC environment requires further investigation after implementation.

From the operational staff meetings, themes were generated from which the researcher was able to deduce certain characteristics that the novel triage system should strive to address. By doing so, some of the issues and concerns raised by the participants will be addressed and ultimately contribute to the success of the novel triage system. The novel triage system should be: easy to understand and use,

objective and auditable, quick and efficient, standardisable across all four ECs, and able to handle large and small patient volumes.

6.5.2 *Triage advisory committee*

The establishment of the triage advisory committee and the meetings that ensued was central to this project. This was the platform for analysis, discussion, reflection, planning, development and design. The first meeting was an initial scoping meeting that allowed the committee to become familiar with the data that was already captured in chapters four and five. The decision to combine categories one with two and four with five seemed reasonable; having a three-level triage system was after all not a new concept. Most triage systems throughout the world have originated from a three-level base and was later expanded to include additional levels purely to create further acuity delineation within high volume ECs.(19,40,58,94) The decision to downscale the number of triage levels was not only based on the acuity findings from chapters 4 and 5 alone, but also on how they were managed within the ECs: high acuity cases (e.g. categories one and two) were managed and seen within similar timeframes; low acuity cases (e.g. categories four and five) were also managed and seen within similar timeframes. Overall timeframes were quite short. This allowed matching of the number of triage levels with the patient flow and input requirements.

The second and third triage advisory committee meetings focussed on the establishment of a triage system direction and the development of the novel triage system. This lead to two specific aims that the committee felt encapsulated their goals for triage within the four Mediclinic Middle East ECs. The two aims were to detect and treat critically ill patients quickly and to improve the flow of patients through the ECs. These goals were similar to some of the goals found within existing international triage systems.(56–59) To address some of the issues raised during the operational staff meetings, it was decided to go with a simple approach that incorporated early warning scores and clinical descriptors, similar to what was currently being used in-hospital to monitor patient observations. A large portion of the novel triage system development was deciding which early warning scores and

clinical descriptors were to be deemed appropriate within the Mediclinic Middle East EC patient context. This process was directed by established guidelines, and employed parts of the existing triage systems that had already undergone extensive clinical testing, as the basis for the novel triage system. (56–59)

6.5.3 Limitations

It is understood that more complex qualitative methodology (i.e. formal focus groups, content analysis, etc.) would have yielded richer data sets. However, given the timeline pressures (i.e. Joint Commission International's review) and resources available for the entire thesis, this was simply not feasible. As one part of a more complex mixed-component design, it was felt that sufficient information was obtained through the action research approach used in this study that could be used in conjunction with what was already known and what was still to be collected from other parts of the thesis.

Qualitative research usually comes with a myriad of potential limitations because it deals with people. Individuals are easily influenced by their surroundings, state of mind, emotions, perceptions, etc. and information is gathered that are of personal accounts, experiences and understanding.(132,213–215) It was most important for this study to create an open environment for participants to relay and share information. However, cognisance of the fact that participants could have been reserved in their expression and therefore possible issues may have been overlooked or withheld. The direct involvement of the researcher could also have provided some limitations to open and free expression by the participants. The researchers' personal biases could also have affected the outcomes and directions of some of the meetings, however, it was necessary to some degree to keep the project's forward momentum on the right path. The researcher assumed the role of facilitator by guiding the participants and the action research process with minimal interference as to the content being delivered.

During the initial stakeholder meetings, it was necessary to use volunteer research assistants to meet with the participants and collect the data. The assistants were required as the researcher had a limited amount of time involving the participants without disrupting EC operations. It was acknowledged that these research assistants were not experts in data collection, however, they were able to connect with the participants on an equal and professional level, and were able to elicit responses from the participants that could have been missed if the meetings were too formal. It was further recognised that these assistants could have brought their own personal bias to the data, influenced the participants' responses, or manipulated the data. The volunteers that were chosen for this task were highly commended by their unit managers for collecting the data in the correct manner. The informal manner of observational data capture could also have resulted in concepts being missed, however, with data from four ECs being grouped together there was strong confidence that all the ideas and views expressed from the participants were captured.

It was recognised that not all the required triage advisory committee members could attend all the meetings due to organisational requirements. The members of the committee were all active, some holding senior management positions within Mediclinic Middle East at various facilities and therefore it was sometimes difficult to schedule meetings that everyone could attend. It was agreed from the beginning that each meeting should consist of at least two medical directors, two EC medical heads and two EC unit managers for the meetings to hold value and decision making capability for the progression of this project. To keep the project's momentum going forward, it was necessary to keep to a relatively fixed schedule. This was further addressed by having the Mediclinic Middle East corporate secretary block off the meeting dates and times well in advance. Although not all the members could attend all the meetings, at least the agreed minimum requirement of participants was reached at each meeting in order to proceed.

The triage advisory committee consisted of senior Mediclinic Middle East management and thus cognisance was taken by the researcher during each meeting

to allow for all members to have an equal share in the discussions and debates. It is however understood that the senior managers had extensive discretion over the business operation and thus the clinical aspects as well. Throughout the meetings it was clear that not all discussions and decisions were purely clinical, but did involve a great deal of business sense and approach to addressing some of the issues. This was welcomed as the ultimate goal was to have a triage system that worked for Mediclinic Middle East both clinically and from a business standpoint. However, the focus and priority was always in the patient's best interest.

6.6 Chapter summary

This study highlighted the opinions and experiences of the operational stakeholders regarding the use of triage systems. They brought information that substantiated the findings from chapters 4 and 5 as well as introduced new information that was crucial in deriving validation criteria for a novel, standardised, triage system for Mediclinic Middle East. By applying the action research design of this project to the development of this novel triage system, a triage advisory committee was established. This committee was able to evaluate the data already uncovered and used it to start with conceptual designs of the novel triage system for Mediclinic Middle East. The committee was able to develop an initial version 1 of the novel system and recognised that further data was required to refine the system. The first three triage advisory committee meetings were held and presented within this chapter. In keeping with the iterative approach of action research, the fourth and fifth meetings are presented in chapters 7.A and 8.A, respectively.

Chapter 7

7 Delving into Mediclinic Middle East's emergency centres

The Mediclinic Middle East triage advisory committee recognised that more data from the current emergency centre (EC) triage operational models were required to further develop and refine the novel triage system. The approach of this chapter's study is very similar to the study presented in chapter 4. There are a few additions based on the decisions made and instructions provided from the triage advisory committee in chapter 6. These additions include capturing patient flow timeframes, descriptor use and calculating a triage allocation based on version 1 of the novel triage system.

7.1 Aim

The aim of this part of the thesis was to describe, compare and correlate the triage allocations at the four Mediclinic Middle East ECs in terms of demographics, case load, principal diagnosis, patient flow timeframes, clinical descriptors and version 1 triage category allocations of the novel triage system.

7.2 Objectives

1. To describe the demographics, case load, triage category allocations, principal diagnoses, patient flow timeframes and clinical descriptors collectively and individually for the four ECs over the study period.

2. To compare and correlate the triage category allocations against the hypothetically modelled allocations of version 1 of the novel triage system.

7.3 Methods

7.3.1 Study design

An observational, cross sectional study was conducted through prospective capture and evaluation of patient medical records within the four Mediclinic Middle East ECs. The STROBE statement checklist for reporting observational studies was used as a framework to report the findings presented.(185)

7.3.2 Setting, population and sample size

Medical records from patients triaged in each of the four ECs over a period of one month were evaluated. The month of August 2015 was selected as it was known to be the least busy month within the four ECs, therefore the addition of data capturing for this study would have had the least operational impact during this month. In contrast to the data collected over a six-month period in chapter 4, it was decided by the triage advisory committee to collect a smaller, adequate sample that would be representative of the larger six-month sample.

To achieve this, a proportional sample size with a 95% confidence level was calculated based on the population of patient records from each of the four ECs for each of the six months. Proportional sampling divides the population into sub-populations and determines the sample amount based on the ratio between the sub-populations. (216,217) During the analysis of the EC caseloads in chapter 4, it was found that the proportion of cases seen between each EC every month was the same irrespective of the amount of cases. The mean proportion of the six months would thus be the value used in this chapter's sample calculation (Table 7.1). The sample was evaluated against the case numbers from August 2014. It was found that August 2015 would provide more than sufficient cases to meet the sample's requirement. Although the sample calculated represented less than 20% of the cases seen during August 2014, the triage advisory committee decided to utilise the whole month of August 2015 for data collection for two reasons: to maintain the same standard of record keeping throughout the whole of August 2015, and to compensate for data loss due to incomplete records. Following the estimation of the sample size requirements based

on proportion, the sample numbers were less than 5% of the total population during the six-month period and thus a finite population correction factor was not required. Provisional calculations of this correction factor indicated a sample reduction of only five cases based on the population and thus this was found not to be substantial, and with the projected sample to be much greater than required the correction factor was rejected.

Table 7.1 Calculation of required sample size against projected sample (216,217)

Sample size calculation: $\boldsymbol{nr = (1.96)^2 pq/d^2}$

*n*r: required sample size

p: proportion of the population having the characteristics

q: 1 – *p*

d: degree of precision (alpha = 0.05)

	WH	CH	CS	IB
$\boldsymbol{1.96^2}$		3.8416		
p	0.48	0.36	0.09	0.06
q	0.52	0.64	0.91	0.94
$\boldsymbol{d^2}$		0.0025		
nr	384	355	127	90
August 2014	4087	3015	760	491

WH, Welcare hospital; CH, City hospital; CS, Al Sufouh clinic; IB, Ibn Battuta clinic

7.3.3 Data collection

Electronic and manual platforms were used to collect the required data. The initial electronic data was sourced similar to methods used in chapter 4, through the Mediclinic Middle East medical records department. The capture of the data, however, was different than in chapter 4. EC staff were instructed by their unit managers to specifically include electronic data fields that was set out for this study, in addition to the usual EC data that they capture. The electronically captured data from the four ECs during the month of August 2015 were collated and provided for

the study in a single Microsoft Excel (© Microsoft Office, Palo Alto, CA) spreadsheet in September 2015.(186) Entries included electronic data captured from each EC's information system. This included patient demographics (e.g. age, gender and nationality), caseloads (as determined by case date stamps), patient flow timeframes (e.g. registration –> triage –> physician –> discharge), vital parameters (e.g. respiratory rate, oxygen saturation, heart rate, blood pressure, temperature and pain score) triage category allocation and principal diagnosis.

It was necessary to capture manual data that was not contained in the Mediclinic Middle East hospital information system. The manual data was captured by the triage nurses completing a one-page tick-box form (Appendix G) during their triage assessment of patients presenting to their ECs. Entries included the triage category allocation, time of triage, time of physician consult, time the patient leaves the EC, the AVPU (a measure of responsiveness: alert, voice, pain, unresponsive), the patients mobility (e.g. walking, with help, stretcher), medical or trauma case, and the associated descriptor, if applicable. Internal training by the unit managers, who were members of the triage advisory committee, was conducted to familiarise the staff with the content of the data collection form. Medical record stickers with patient identifiers were attached to the form so that the data could be merged later on with the electronic data. Clerical staff from the four ECs captured the manual data from the forms onto a custom Microsoft Excel spreadsheet daily. The researcher collected the spreadsheets from the four ECs and used the patient identifiers to merge the electronic and manual datasets through the Microsoft Excel merge data function.

Patient identifiers (e.g. names, surnames and medical record numbers) were included in the dataset shared with the researcher in order to provide an identifier for merging electronic data with manual data. Following this, all identifiers were stripped from the sample, prior to analysis. The manual data capture forms were collected from the four ECs and kept secure by the researcher as per the research protocol. These forms were handed back over to Mediclinic Middle East to keep for their records at the end of the study.

7.3.4 Variables and bias

Only records with all the relevant data points were included. Records with missing data points were identified, filtered and removed from the database prior to analyses using the Microsoft Excel filter option.(186) Removing records from the dataset may have introduced exclusion bias that could have resulted in the removal of potential outliers such as high acuity cases. Removing incomplete records before analysis ensured that a complete dataset was available with all the data points present. In contrast to the exclusion method used in chapter 4, it was decided to make this blanket exclusion across all the variables prior to analysis. This was done so that a uniform sample was available as all the data points were necessary to make accurate estimations and calculations of the version 1 novel triage system allocations. There were no obvious reasons for data points to be missing other than random omission from the staff to make entries, and thus obtaining these missing data points would not be possible. Even with a minor loss of records, the sample size was still large enough to appropriately reflect the proportions of the population. The records that were removed are reported in the results section.

7.3.5 Data analysis

The data captured for this study was very similar to the data from chapter 4 and thus a similar approach to the analysis was taken. Most of the data were either nominal or ordinal with the exception of age being ratios and in this study the inclusion of timeframes which were interval. The use of non-parametric descriptive statistics was continued, with the median as a measure of central tendency measure. The analysis of patient demographics, caseload, principal diagnoses and triage category allocations were done in the exact same way as in chapter 4 using histograms and frequency tables to describe distributions. Similar single-factor ANOVA and two-tailed Spearman's correlation coefficient tests with a precision level of $p<0.05$, was applied to determine the variance and relationship of the triage category allocations among the four ECs. The null hypothesis remained constant in stating that there was no significant difference in the triage category allocations of the four ECs.

There were two specific additions to this study. These included the analysis of patient flow timeframes within the four ECs, and the comparison of the triage category allocations assigned to study subjects against that of a hypothetical model of allocations. The latter that were made by applying the parameters of version 1 of the novel triage system. The timeframes as patients moved through the ECs were captured at specific points in the patient's journey from entering the EC to leaving the EC by either being discharged or admitted to hospital. This analysis was done to establish baseline time targets for each tier of the novel triage system, to determine how quickly high acuity cases are being managed, and to see if there was any underlying pattern emerging from the timeframe medians. An observational analysis was done by looking at the medians between the time points for each EC and making realistic comparisons thereof. Factors such as timestamp input delays, inaccurate time readings, adjusted time inputs etc. that could impact and alter these timeframes coupled with the uncertainty of their accuracy and reliability, did not warrant in-depth variance and relationship testing.

Comparing the actual triage category allocations made with version 1 of the novel triage system was a difficult and complicated task. No such comparison has even been attempted as far as could be determine through a thorough literature search. In simple terms, the idea was to see how version 1's triage category allocations compared against those that were actually allocated to patients during the study period. The limitations and potential bias for such analyses is forthcoming. These included having only electronic data available to interact with and lacking direct subjective input (i.e. nurse- patient- triage system interaction) In addition, a comparison would have to be done between a five-level system and a three-level triage system as described in chapter 6. The current five-level systems were adjusted to a three-level and reflected the triage advisory committee's suggestion to combine categories one and two, and four and five. On the positive side, using data this way would not affect patients directly and could only benefit by giving the triage advisory committee a rough idea as to the direction of the system's development. It was already known that the existing triage systems in place were performing reasonably well, though not ideal.

It was necessary to have all the data to make a triage category allocation available from version 1 of the novel triage system. This consisted of the early warning score vital sign parameters and clinical descriptors as described in chapter 6. To determine the triage category allocations that would hypothetically be made, initial calculations were done using a Microsoft Excel spreadsheet to allocate early warning score values (i.e. zero to three) based on the patient's vital parameters.

Any single vital parameter that scored a three was automatically given the triage category one. With the totals calculated, a score of seven or above was allocated a triage category of one, a score of four to six a triage category of two, and a score of zero to three a triage category of three. The early warning score's triage category allocation served as a baseline and from there focus shifted to the clinical descriptors. The clinical descriptors only allowed for triage categories to be upgraded from a lower acuity category to a higher acuity category (e.g. from two to one). The triage advisory committee already decided on the levels of the clinical descriptors and thus any patient that was allocated a clinical descriptor could be upgraded to that level from the baseline allocation. This provided a final three-level triage category allocation that could be similarly compared by using the actual allocations as the reference standard. Over- and under-triage of the adjusted three-level rates were also calculated.

7.4 Results

7.4.1 Sampled description

There was a total of 7311 electronic and 6754 manual patient records captured between from the four ECs during the month of August 2015 (Table 7.2). When the data was combined in a single spreadsheet there were some records captured electronically but not manually and vice versa, thus resulting in a smaller, combined number of 6320 records. Duplicate and missing entries were removed leading to a further loss of 1888 records. Although there was a total data loss of 30% of the data, the minimum required sample was reached for each EC.

Table 7.2 Sampled records inclusion and exclusion from patient records at the four emergency centres (August 2015)

	WH	CH	CS	IB	Total
Required sample	**381**	**352**	**126**	**87**	**946**
Final sample	**2333**	**1199**	**496**	**404**	**4432**
Electronic data	3694	2536	597	484	7311
Manual data	3395	2324	577	458	6754
Combined	3216	2082	568	454	6320
Combined proportion	0.51	0.33	0.09	0.07	
Duplications	277	230	37	24	568
Missing entries	606	653	35	26	1320
Data loss	883	883	72	50	1888
% Data loss	27%	42%	13%	11%	30%
% Above required sample	612%	341%	394%	464%	468%

WH, Welcare hospital; CH, City hospital; CS, Al Sufouh clinic; IB, Ibn Battuta clinic

7.4.2 Patient nationality distribution

Of the 4432 sampled records, a total of 119 nationalities were recorded with 3265 (73.7%) representing the top ten nationalities (Table 7.3). The largest, single population group was Emirati, from the United Arab Emirates (n=12361; 21.9%). The Indian population (n=643; 16.1%) was the only other nationality that came close to matching the Emirati population.

Table 7.3 Top ten nationalities from patient records at the four emergency centres (August 2015) (n=4432)

Rank #	Nationality	n	%
1	Emirati	1083	24.4
2	Indian	643	14.5
3	Filipino	312	7.0
4	Pakistani	237	5.4
5	British	223	5.0
6	Egyptian	213	4.8
7	Lebanese	209	4.7
8	Jordanian	183	4.1
9	American	87	2.0
10	Syrian	75	1.7

7.4.3 Patient age and gender distribution

Of the 4432 sampled records the gender distribution was nearly equal with 2314 (52.2%) female and 2118 (47.8%) male records (Figure 7.1). The age-group category with the most records was the 30 – 40 years old group with 1035 (23.5%) records. The age group considered to represent children (i.e. 0 – 10 years) consisted of 196 (4.4%) and the age group considered to be the workforce (i.e. 20 – 50 years) consisted of 3611 (81.5%) records. The median age was 33 years with an interquartile range of 27 to 39 years.

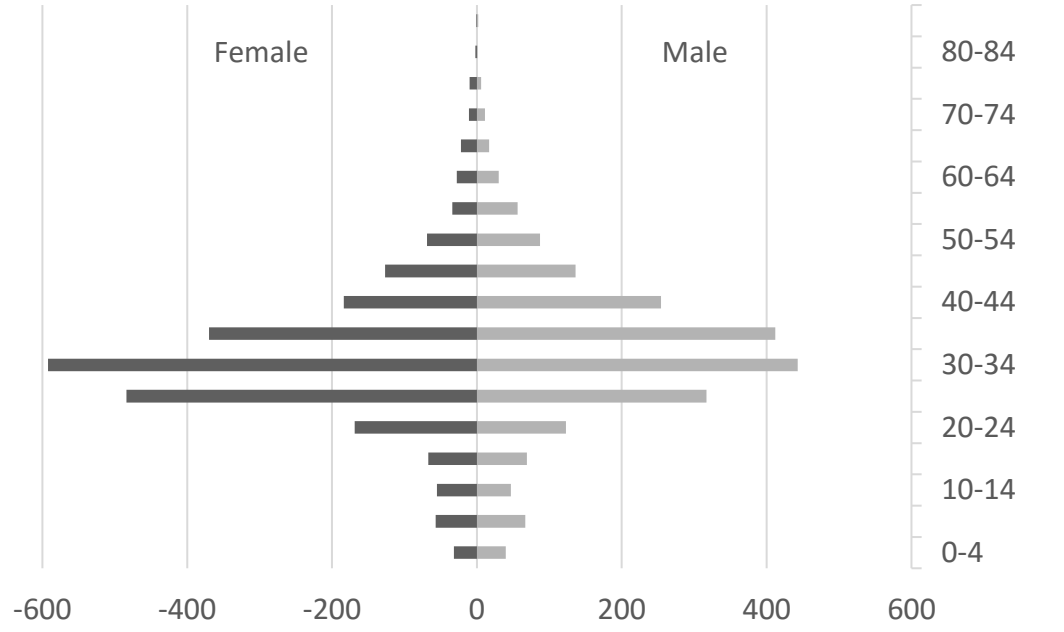


Figure 7.1 Age and gender distribution from patient records at the four emergency centres (August 2015) (n=4432)

7.4.4 Principal diagnosis profile

Of the 4432 sampled records, it was found that the largest single diagnosis reported during the study period was acute upper respiratory infection (n=535; 12.1%) (Table 7.4). This study's sample was limited by diagnosis names as described in the principal diagnosis profile in chapter 4. There was only a single category one case reported in the sample and 24 (0.5%) category two cases. Although some presentations were considered low acuity, chest pain could have been considered a high acuity diagnosis and subsequently featured as the top diagnosis of category two cases and ranked fifth overall.

Table 7.4 Top principal diagnoses from patient records at the four emergency centres (August 2015)

Triage category one (n=1)
Syncope and collapse

#	Triage category two (top five, n=24)	n	%
1	Chest pain	3	12.5
2	Infectious gastroenteritis and colitis	2	8.3
3	Dizziness and giddiness	2	8.3
4	Non-infective gastroenteritis and colitis	2	8.
5	Abdominal pain	2	8.3

#	All triage categories (top five, n=4432)	n	%
1	Acute upper respiratory infection	535	12.1
2	Infectious gastroenteritis and colitis	169	3.8
3	Abdominal pain	158	3.6
4	Acute pharyngitis	145	3.3
5	Chest pain	138	3.1

7.4.5 Triage category allocation

Of the 4432 sampled records, triage category four was allocated most often (n=2423; 54.7%). Conversely, category one was only allocated once (Table 7.5 and Figure 7.2). The majority of allocations were made towards the mid to low acuity spectrum (i.e. categories three to five) (n=4407; 99.4%) whereas high acuity cases (categories one and two) only made up a low proportion of allocations (n=25; 0.6%). The p-value ($p=0.29$) was more than the precision level of $p<0.05$ and the F-value ($F=1.37$) was less than the F-critical ($Fcrit=3.24$) (Table 7.6). The correlation of the triage category allocations among the four ECs was high (Table 7.7). Welcare hospital, Al Sufouh clinic and Ibn Battuta clinic reported close correlation, however, City hospital did not correlate with these ECs (Figure 7.3).

Table 7.5 Triage category allocation distribution from patient records at the four emergency centres during (August 2015) (n=4432)

	WH	CH	CS	IB	Total	
Total	**2333**	**1199**	**496**	**404**	**4432**	
Category	**n**	**n**	**n**	**n**	**n**	**%**
1	1	0	0	0	1	0.02
2	1	19	1	3	24	0.5
3	391	613	69	30	1103	24.9
4	1483	367	331	242	2423	54.7
5	457	200	95	129	881	19.9

WH, Welcare hospital; CH, City hospital; CS, Al Sufouh clinic; IB, Ibn Battuta clinic

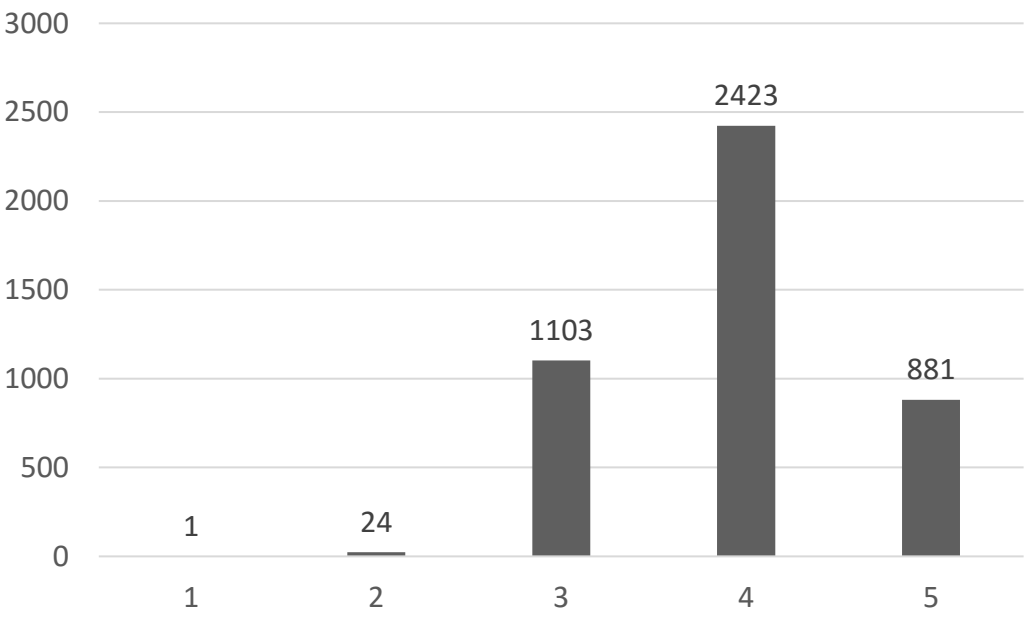


Figure 7.2 Triage category allocation from patient records at the four emergency centres (August 2015) (n=4432)

Table 7.6 ANOVA* of the triage category allocation distribution from patient records at the four emergency centres during (August 2015)

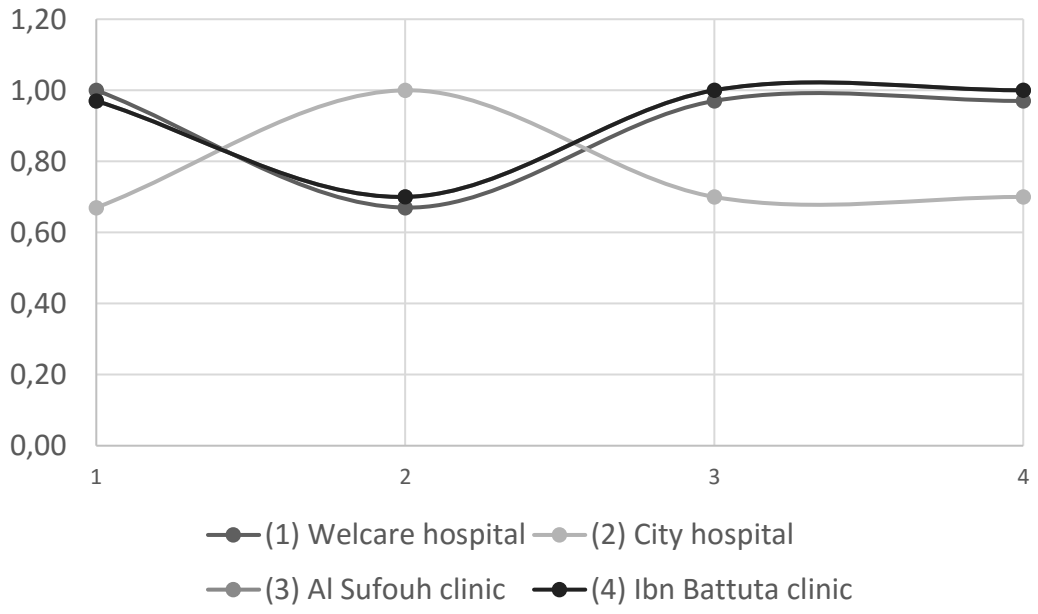
Source of variation	F-distribution	p-value	F-critical
Emergency centres	1.369	0.288	3.239

ANOVA, analysis of variance; *, single-factor without replication and alpha 0.05

Table 7.7 Spearman's correlation* of the triage category allocation distribution from patient records at the four emergency centres (August 2015)

	WH	CH	CS	IB
WH	-	0.67	0.97	0.97
CH	0.67	-	0.70	0.70
MS	0.97	0.60	-	1.00
IB	0.97	0.70	1.00	-

WH, Welcare Hospital; CH, City Hospital; CS, Al Sufouh clinic; IB, Ibn Battuta clinic; *, two tailed coefficients with alpha 0.05



Note: line (3) and (4) are identical and thus appear as only one line

Figure 7.3 Spearman's correlation of the triage category allocation distribution from patient records at the four emergency centres (August 2015)

7.4.6 EC patient flow timeframes

Of the 4432 sampled records there were only 2997 records available for the timeframe: registration –> triage, and 4232 records for: registration –> consult. The other timeframes had all 4432 records available for the entire sample. These record exclusions were made to avoid confusion where the registration time was recorded as being later than the triage or consult times, thus resulting in a negative time difference. It was found that the overall median time from registration –> triage was less than 10 minutes (interquartile range 0 – 6 minutes) and registration –> physician consult was less than 20 minutes (interquartile range 0 – 19 minutes) (Table 7.8). The median triage –> consult times support the notion that patients were seen by a physician within 25 minutes (interquartile range 0 – 22 minutes) from the time they are triaged.

Welcare hospital was the only EC that saw a category one case; a physician saw them immediately. Category two cases were also seen immediately by physicians in all the ECs except for City hospital. They reported a median of 16 minutes (interquartile range 12 – 19 minutes). Timeframes data from City hospital showed a marked increase compared to the other ECs in the time it took for patients to be seen by a physician. In most cases, the median time was three to four times higher than the other ECs. The overall lengths of stay in the ECs were much longer for the mid to high acuity cases (i.e. categories one, two and three) (interquartile range 1 hour 13 minutes to 2 hours 44 minutes) with the lengths of stay of the low acuity cases (i.e. categories four and five) (interquartile range 32 minutes to 49 minutes) being markedly less. This decrease in lengths of stay of low acuity cases as compared to the mid to high acuity cases is further evidenced by the decreased interquartile range times from physician consult –> patients leaving the EC being 15 minutes to 31 minutes. Overall, there was an inverse relationship between acuity level and time-to-physician, and a direct relationship between the acuity levels and the length of stay in the EC. The median timeframes for patients to be seen by a physician increased as the acuity level decreased, and the length of stay in the EC decreased as the acuity level decreased.

Table 7.8 Patient flow timeframes* per triage category from patient records at the four emergency centres (August 2015)

Registration at front desk → Triage at nurses' station (n=2997)				
Category	**WH**	**CH**	**CS**	**IB**
1	**0** (0 – 0)			
2	**0** (0 – 0)	**0** (0 – 1)	**0** (0 – 0)	**0** (0 – 0)
3	**5** (2 – 11)	**3** (1 – 7)	**5** (3 – 10)	**2** (0 – 6)
4	**5** (2 – 10)	**3** (1 – 6)	**3** (1 – 8)	**3** (1 – 7)
5	**6** (3 – 11)	**3** (1 – 7)	**4** (2 – 11)	**4** (2 – 8)
Registration at front desk → Consult with a physician (n=4232)				
Category	**WH**	**CH**	**CS**	**IB**
1	**0** (0 – 0)			
2	**0** (0 – 0)	**16** (12 – 29)	**0** (0 – 0)	**0** (0 – 0)
3	**12** (7 – 20)	**17** (9 – 29)	**9** (5 – 16)	**6** (3 – 10)
4	**13** (7 – 20)	**19** (10 – 31)	**7** (4 – 14)	**7** (4 – 11)
5	**14** (8 – 20)	**19** (10 – 32)	**8** (6 – 19)	**8** (5 – 13)
Registration at front desk → Patient leaves emergency centre (n=4432)				
Category	**WH**	**CH**	**CS**	**IB**
1	**73** (73 – 73)			
2	**41** (41 – 41)	**184** (133 – 229)	**127** (127 – 127)	**33** (33 – 85)
3	**111** (62 – 157)	**125** (82 – 171)	**66** (40 – 115)	**58** (40 – 104)
4	**61** (33 – 108)	**48** (33 – 80)	**29** (19 – 51)	**32** (23 – 50)
5	**32** (22 – 49)	**41** (27 – 64)	**29** (18 – 38)	**24** (18 – 35)
Triage at nurses' station → Consult with a physician (n=4432)				
Category	**WH**	**CH**	**CS**	**IB**
1	**0** (0 – 0)			
2	**4** (4 – 4)	**20** (11 – 28)	**2** (1 – 3)	**2** (1 – 3)
3	**7** (4 – 12)	**20** (12 – 30)	**4** (2 – 5)	**4** (3 – 5)
4	**7** (4 – 12)	**21** (13 – 33)	**4** (3 – 5)	**5** (3 – 7)
5	**6** (4 – 13)	**22** (12 – 33)	**4** (3 – 7)	**5** (3 – 8)

Triage at nurses' station → Patient leaves emergency centre (n=4432)				
Category	**WH**	**CH**	**CS**	**IB**
1	**90** (90 – 90)			
2	**45** (45 – 45)	**196** (137 – 232)	**169** (169 – 169)	**41** (39 – 91)
3	**106** (59 – 154)	**130** (87 – 173)	**70** (37 – 114)	**58** (38 – 99)
4	**56** (27 – 102)	**52** (36 – 83)	**24** (16 – 44)	**28** (21 – 45)
5	**23** (16 – 42)	**44** (31 – 63)	**21** (15 – 38)	**21** (16 – 29)
Consult with a physician → Patient leaves emergency centre (n=4432)				
Category	**WH**	**CH**	**CS**	**IB**
1	**90** (90 – 90)			
2	**37** (37 – 37)	**164** (118 – 209)	**141** (141 – 141)	**37** (36 – 88)
3	**95** (49 – 140)	**109** (63 – 150)	**66** (26 – 105)	**55** (33 – 96)
4	**42** (17 – 90)	**25** (15 – 51)	**18** (11 – 40)	**22** (15 – 41)
5	**14** (10 – 26)	**18** (12 – 31)	**15** (11 – 28)	**14** (11 – 18)

WH, Welcare hospital; CH, City hospital; CS, Al Sufouh clinic; IB, Ibn Battuta clinic; *, each value: **median** (interquartile range) is expressed in minutes

7.4.7 Descriptor allocations

Of the 4432 sampled records there were only 1446 records that were allocated a descriptor (Table 7.9). Of these clinical descriptors, abdominal pain with (n=663; 15%) was the most recognised symptom with chest pain (n=191; 4.3%) and moderate trauma (n=132; 3%) the only other clinical descriptors with more than a hundred allocations. Of the 62 clinical descriptors, 29 (46.8%) did not receive an allocation.

Table 7.9 Triage descriptor allocation distribution and top five from patient records at the four emergency centres (August 2015)

Descriptor	n	Descriptor	n
abdominal pain	663	joint swelling and pain	69
allergic reaction – severe	7	light-headedness	13
anxiety – severe	3	obstructed airway	0
arrest – code/resuscitation	0	obvious deformity	0

asthma – severe	1	pain unresponsive to analgesics	85
burn – facial or inhalation	2	palpitations	37
burn less than 20%	13	photophobia	1
burn more than 20%	0	poisoning/overdose	0
cardiac – neck jaw or arm pain	3	pregnancy and trauma	2
chemical exposure	1	pregnancy and vaginal bleeding	21
chest pain	191	prolapsed cord	0
child – looks severely unwell	0	psychosis – acute	0
confusion – new onset	0	pulsatile bleeding	0
constipation – severe	3	respiratory distress – mild	37
dehydration – adult – moderate/severe	40	respiratory distress – moderate	2
dehydration – child – moderate/severe	8	respiratory distress – severe	0
dialysis problems	0	restlessness/irritability – severe	0
dislocation of finger or toe	0	ruptured membranes	0
eye injury	22	seizure – current	0
fracture – closed	4	seizure – post ictal	0
fracture – open	0	shock – moderate	0
haemoptysis	0	shock – severe	0
haemorrhage – controlled	0	stroke – acute	0
haemorrhage – uncontrolled	0	sudden throat/tongue swelling	21
head injury with risk features	10	threatened limb	0
history of loss of consciousness	11	trauma – major/severe	2
hyperglycaemia > 17mmol/l	0	trauma – moderate	132
hypoglycaemia < 3mmol/l	0	uncontrollable itching	4
infant < 1-year-old	0	unresponsive	1
infection – severe	3	vomiting fresh blood	2
joint dislocation with vascular compromise	0	vomiting persistently	32

#	Allocated clinical descriptors (top five, n=4432)	n	%
1	Abdominal pain	663	15.0
2	Chest pain	191	4.3
3	Trauma – moderate	132	3.0
4	Pain unresponsive to analgesics	85	1.9
5	Joint swelling and pain	69	1.6

7.4.8 Comparative analyses of allocated triage categories

Of the 4432 sampled records with the actual triage category allocations, categories one and two were combined to form category A (n=25 cases), triage category three formed category B (n=1103 cases), and triage categories four and five were combined to from category C (n=3304 cases). These newly formed, adjusted triage categories were compared to the hypothetical triage category outcomes that version 1 of the three-level triage system would have allocated, as calculated through its early warning score and list of clinical descriptors.

When compared against the actual triage category allocations, the novel triage system attained the same triage category in 2544 (57.4%) cases, over-triaged in 1575 (35.6%) cases and under-triaged in 313 (7.1%) cases (Table 7.10). There would have been 942 (21.3%) more category one cases allocated by the novel triage system of which eight of the 25 cases that received an actual triage category of A would be downgraded to a lower category. Should the three levels of version 1 of the novel triage system have been applied, then hypothetically, the totals would have been 959 (21.6%) category one allocations, 966 (21.8%) category two allocations, and 2507 (56.6%) category three allocations.

Table 7.10 Overall comparison of triage category allocation distribution based on a hypothetical three-level system from patient records at the four emergency centres (August 2015)

		Similar triage			Over-triage			Under-triage			Total
n		**2544 (57.4%)**			**1575 (35.6%)**			**313 (7.1%)**			**4432**
OLD	**A**	**B**	**C**	**Total**	**B**	**C**	**Total**	**A**	**B**	**Total**	
NEW											
1	17			**17**	468	474	**942**				**959**
2		330		**330**		633	**33**	3		**3**	**966**
3			2197	**2197**				5	305	**310**	**2507**

7.5 Discussion

One of the most important validation criterion of any triage system is the time-to-physician variable.(56–59) The ultimate goal is to queue patients in such a manner that the larger patient numbers are appropriately coordinated to the smaller physician numbers or resources available.(56–59) The existing triage systems each have time targets set for patients to be seen by a physician (Table 2.8, Chapter 2).(56–59) These time targets were mostly set arbitrarily by the creators of the triage systems based on reasonable expert opinion (i.e. not based on objective findings).(56–59) They were, however, designed with the environment the triage systems would be used in, in mind. With the development of a novel triage system for Mediclinic Middle East, it was decided by the triage advisory committee that they would set their own time targets based on the local EC environment. Although there were observable differences in the overall timeframes of patients as they moved through the four ECs, especially between the two hospitals and two clinics, it was evident that the median time for patients from entering the EC to be seen by a physician was relatively short when compared to the timeframe targets of the existing triage systems. The time-to-physician times for category one and two cases were in line with the set targets of the existing triage systems and would be very difficult to improve upon. Categories three, four and five, however, showed a marked decrease in time-to-physician as compared to the targets of the existing triage systems. This suggested that the time-to-physician targets for Mediclinic Middle East

ECs for all lower acuity cases could be made shorter, which would improve the overall waiting times. Even with the triage advisory committee's decision to develop a three-level triage system, the decrease in time-to-physician times could be applied to this model as the actual time-to-physician times recorded were markedly less irrespective of how triage categories were grouped together.

The clinical descriptors allocated during this study provided an overview of the possible clinical descriptors that could be used in the future within the novel triage system (Table 7.9). Abdominal pain and chest pain were among the most allocated clinical descriptors and were similarly reflected in the principal diagnosis profile (Table 7.4). The allocation of moderate trauma (n=132) was the third most allocated descriptor. This raised interest as treating trauma within private hospitals in the United Arab Emirates is not advocated by the local health authority. These cases could have been a result of patients with trauma attending these ECs for treatment and their condition being such that transfer to a public EC was not required. Further investigation would be required to determine the extent of such trauma cases presenting to the four ECs, but that is beyond the scope of this thesis. Pain was a major factor; clinical descriptors with abdominal pain, chest pain, joint pain, and pain unresponsive to analgesics received the most allocations. This substantiates the triage advisory committee's decision to include a pain score evaluation in the early warning score of the novel triage system, a parameter that usually receives less attention or is omitted in triage systems.(56–59)

The early warning scores and clinical descriptors from version 1 of the novel triage system were used to determine triage category allocations based on the patient records. An initial comparison of these hypothetical allocations using the actual triage category allocations as a reference standard showed positive results in that it came up with a similar triage category allocation 57.4% of the time, over-triaged 35.6% of the time and under-triaged 7.1% of the time. The large increase of category one patients that were allocated from the three-level triage system required further deliberation by the triage advisory committee. These patients would have placed extreme strain on the four ECs' resources had they all needed to be seen

immediately. The unavoidably high over-triage rate and low under-triage rate were in line with what the American College of Surgeons Committee on Trauma (ACSCOT) considers acceptable.(62) These rates were also reported and accepted by other studies that evaluated the validity of triage systems.(24,62,69,77) This initial hypothetical comparison showed that the development of the novel triage system had been proceeding in the right direction by provisionally showing safe and trustworthy triage category allocations.

Similar findings were made in this study overall to corroborate the results in chapter 4 relating to caseload proportion per EC, patient nationality, age, gender, principal diagnosis and triage category distributions. A notable difference was in the age group of children less than ten years old. This study found that the under ten years old age group was considerably smaller at 4.4% than the reported 24.5% in chapter 4. Upon investigation of this occurrence, it was found that a large portion of the excluded records were in this age group due to missing blood pressure readings. This issue was presented to the triage advisory committee for review and resulted in changes made to version 2 of the novel triage system. This included an early warning score directed at children with the removal of the blood pressure measurement for triage purposes. The triage category allocations of this study followed the same distribution as in chapter 4 with category four receiving the most allocations (Figure 7.2). The ANOVA revealed no significant variations (Table 7.6) and the null hypothesis could thus not be rejected.(190,207) The relationship of triage category allocations among the four ECs were similar to that reported in chapter 4, with an almost identical correlation found (Figure 7.3). One EC, City hospital, again stood out from the other three ECs by not correlating to their distributions. Further research is required to evaluate the aberrancy found in this regard.

7.5.1 Limitations

Nearly identical limitations to chapter 4 relating to data capture, principal diagnosis and triage category allocations were experienced in this study and required similar methods of mitigation. The use of electronic and manual data required an extra level

of scrutiny and care to ensure records were secure. All manual records were kept safe by the unit managers and then filed with the Mediclinic Middle East medical records department once the clerical staff were able to transpose the data electronically onto a Microsoft Excel spreadsheet. The use of electronic and manual platforms also led to exclusions; gaining a full sample was reliant on the data points matching up between the platforms. Data points that did not exist in both electronic and manual datasets were removed as well as duplicate records, or records with missing data points. Discrepancies between the electronic and manual records were odd; they were brought to Mediclinic management's attention for a separate investigation to take place that has not been discussed here. However, early reports suggested that for cases where manual records were present but were not reflect electronically, these patients were streamed to outpatient departments and not seen in the EC. On the other hand, for cases where electronic records were present and not reflected manually, operator omission was considered or the EC operations required a bypass of triage for unknown reasons. It is unlikely that these missing data points would have affected the results of this study. It was necessary for this study to have all the data points available for the entire sample to make relevant comparisons. Even though one-third of the total data was lost prior to analysis, the required sample size was met. In fact, more than four times the sample necessary was collected. It was found and acknowledged that a large portion of children's records were excluded due to missing blood pressure entries. This limitation highlighted the need to have a separate early warning score pertaining to children in version 2 of the novel triage system.

Evaluating timeframes was difficult. Most of the time stamps required manual entry and those that were self-generated by the hospital information system still were at the mercy of the entry time. Incorrect times could have resulted from unsynchronised clocks, forgetting to accurately determine and record the times, or making late entries on the hospital information system. It was accepted that some variation of time records existed as this was dependant on human input. Using the medians as a measure of central tendency helped mitigate any absolute outliers that could have nullified the findings. This limitation was also presented to the triage

advisory committee for further deliberation on a possible solution. This was done to ensure accurate timeframe measurements as they are crucial to the novel triage system with respect to meeting its timeframe targets.

A comparison of triage category allocations was performed. This was based on a hypothetical calculation of the triage category allocations from version 1 of the novel triage system. It is acknowledged that adjusting a five-level triage system to match a three-level system by combining categories one with two and four with five may have potentially resulted in altered allocations. Unlikely errors in the hypothetical calculation using the early warning scores and clinical descriptors from version 1 of the novel triage system could further have resulted in altered results. This was an experimental attempt to try and compare actual triage category allocations with calculated allocations based on medical records alone. The subjective input that a triage nurse would have when assessing an actual patient was also lost through this process. Through robust programming within a Microsoft Excel spreadsheet, it was possible to make accurate triage category allocations based on the data and the reference values from the first version of the novel triage system. By using the actual triage category allocations as a reference standard and matching them with the hypothetical model, it was possible to make a reasonably accurate comparison of how the novel triage system would compare against the existing triage systems.

7.6 Chapter summary

This study was able to gather crucial information to aid in the development of the novel triage system. It was able to corroborate the results of chapter 4 relating to the caseload proportion per EC, patient nationality, age, gender, principal diagnosis and triage category distributions. There was a good indication as to what the possible time-to-physician targets would be, and which clinical descriptors were most likely to be included in the next version of the novel triage system. Comparing the triage category allocations between version 1 of the novel triage system and the existing triage systems showed that the development of the novel triage system was on a trajectory to provide a best-fit triage system for Mediclinic Middle East.

Chapter 7.A

7.A Developing version 2 of the novel triage system

The study conducted in chapter 7 gathered additional information on the current EC patient flow timeframes, clinical descriptor uses and comparison of version 1 of the novel triage system against current triage category allocations. As part of the action research process, a reflection on this information was done through another triage advisory committee meeting, to further develop the design of the novel Mediclinic Middle East triage system.

7.A.1 Fourth triage advisory committee meeting

The fourth triage advisory committee meeting (Box 7.1) was held on 6 September 2015 and was attended by eight committee members. This meeting refined the novel triage system and derived version 2 (see below), to be tested against the reference standard (i.e. vignettes) in chapter 5. The time-to-physician targets, adult and child early warning scores and clinical descriptors were decided upon at this meeting (Tables 7.11, 7.12, 7.13 and 7.14).

Box 7.1 Fourth triage advisory committee meeting's minutes

Purpose

- To present and evaluate the findings of the phase four [Chapter 7] data.
- To refine the adult and child early warning score values and clinical descriptors and to finalise version 2 of the novel triage system.
- To finalise arrangements for the phase five [Chapter 8] evaluation of version 2 of the novel triage system.

Main outcomes

- The committee is satisfied with the findings made during the phase four [Chapter 7] data collection which aids them in making decisions to refine version 2 of the novel triage system.
- The committee raises concern about combining the current triage categories one and two. This concern stems from the large amount of category one

allocations that would be made based on the comparison and would not be reflective of actual events.

- The committee deliberates extensively about the impact of redefining triage category one (by combining the current one and two categories). International understanding of triage category one is very specific, and its impact when reported to the local health authority may lead to undesired medico-legal implications should any of those cases not be attended to immediately. It is decided by the committee to keep the traditional category one definition intact which would in turn lead to the initial three-level triage system to become a four-level triage system.
- Based on the time-to-physician findings the committee deliberates and reaches consensus on the descriptors and timeframe targets for the now four-level triage system [Table 7.11]
- The committee decides to separate the early warning scores for adults (i.e. above 12 years or puberty) and children (i.e. age one to 12, or puberty). For the adult and children early warning score, it is decided to remove the term unresponsive as that would automatically indicate a category one case, changes in the pain score values are made and that any vital parameter score of three would now indicate an automatic triage category two [Table 7.12]. For the child early warning score, the recommended in-hospital Paediatric early warning score guide would provide the values, removing blood pressure from the list and altering the respiratory and heart rates accordingly [Table 7.13]. The committee recognises that an infant (i.e. younger than 1 year) early warning score also needs to be developed in the future [beyond this research] with input from experts outside this committee.
- Based on the clinical descriptor allocations made, the committee deliberates and reaches consensus on which descriptors would be used and what triage category they would apply to [Table 7.14]. Triage category four would not have any descriptors as it is the lowest possible category that includes all possible clinical conditions not covered by categories one, two and three.
- The committee reaches consensus that version 2 of the now four-level novel Mediclinic Middle East triage system is ready to be tested in a similar study way to the study that was conducted in phase two [Chapter 5] by nursing staff evaluating vignettes, and then to compare phase five [Chapter 8] results to those obtained through phase two [Chapter 5]

Action points

- The committee recommends that orientation material be prepared by the researcher and delivered to the nursing staff prior to commencement of the phase five [Chapter 8] study for them to familiarise themselves with the new system. Orientation material should consist of an instructional guide with triage algorithms as well as a brief instructional video.
- The committee recognises that the reference standard used to evaluate the vignettes in phase two [Chapter 4] would have to be changed to reflect the

definitions and levels of the new, four-level novel triage system. It was decided that the same 50 vignettes would be used but that they would need to be objectively triaged beforehand using the new, novel triage system to establish the new reference standard.

- The final triage advisory committee meeting for this research project should be scheduled after the phase five [Chapter 8] data has been collected and provisionally analysed by the researcher.

EC, emergency centre; all wording in brackets, e.g. [Chapter 7], has been added for reporting purposes in this thesis

Table 7.11 Committee's version of triage category descriptions and time-to-physician targets

Category	Description	Time-to-physician
1	Resuscitation	Immediate
2	Emergent	Within 15 minutes
3	Urgent	Within 30 minutes
4	Non-Urgent	Within 60 minutes

Table 7.12 Triage advisory committees' early warning scores for adults (> 12 years)

Parameter	3	2	1	0	1	2	3
AVPU		New Confusion		Alert	Voice	Pain	
RR (rpm)	≤ 8		9 – 11	12 – 20	21 – 24	25 – 29	≥ 30
SpO_2 (%)	≤ 91%		92 – 93%	≥ 94%			
HR (bpm)	≤ 40		41 – 50	51 – 100	101 – 110	111 – 129	≥ 130
SBP (mmHg)	≤ 70	71 – 80	81 – 100	101 – 199		≥ 200	
Temp (°C)	≤ 35		35.1 – 36	36.1 – 38	38.1 – 39	39.1 – 41.5	≥ 41.5
Pain*				0 – 2	3 – 4	5 – 7	8 – 10

AVPU, alert-voice-pain-unresponsive; RR, respiratory rate; rpm, respirations per minute; SpO_2, oxygen saturation; %, percent oxygen; HR, heart rate; bpm, beats per minute; SBP, systolic blood pressure; mmHg, millimetres of mercury; Temp, temperature; °C, degrees Celsius; *, pain score up to 10 with 10 indicating the most severe

Table 7.13 Triage advisory committees' early warning scores for children (1 – 12 years)

Parameter	3	2	1	0	1	2	3
AVPU		New Confusion		Alert	Voice	Pain	
RR (rpm)	≤ 15	16 – 20		20 – 30	31 – 40	41 – 44	≥ 45
SpO_2 (%)	≤ 91%		92 – 93%	≥ 94%			
HR (bpm)	≤ 60	60 – 70		70 – 120	121 – 130	131 – 139	≥ 140
Temp (°C)	≤ 35		35.1 – 36	36.1 – 38	38.1 – 39	39.1 – 41.5	≥ 41.5
Pain*				0 – 2	3 – 4	5 – 7	8 – 10

AVPU, alert-voice-pain-unresponsive; RR, respiratory rate; rpm, respirations per minute; SpO_2, oxygen saturation; %, percent oxygen; HR, heart rate; bpm, beats per minute; mmHg, millimetres of mercury; Temp, temperature; °C, degrees Celsius; *, pain score up to 10 with 10 indicating the most severe

Table 7.14 Triage advisory committee's clinical descriptors

Category 1 – Red		
unresponsive and/or arrest – code		
Category 2 – Orange		
allergic reaction – severe	chest pain	burn – major, facial or inhalation
ruptured membranes	neonate	respiratory distress – severe
prolapsed cord	trauma – major	hypoglycaemia – symptomatic
seizure – active	stroke	joint dislocation with vascular compromise
Category 3 – Yellow		
dizziness	abdominal pain	pregnancy – trauma or vaginal bleeding
obvious limb deformity	burn – minor	hyperglycaemia – symptomatic
palpitations	seizure – post ictal	respiratory distress – moderate
photophobia	eye injury	restlessness/irritability – severe

poisoning/overdose	fracture – open	dehydration – child – moderate/severe
trauma – moderate	threatened limb	history of loss of consciousness
Category 4 – Green		

7.A.2 Chapter summary

A four-level triage system was created. This was done by retaining the current categories one, two and three and combining categories four and five into one category. Additionally, new timeframes provided the foundation for the time-to-physician targets for each triage category allocation and an early warning score for children was added to the system. This was done to address some of the incongruous vital sign parameters between adults and children and to eliminate the systolic blood pressure requirement for triage purposes. The triage advisory committee reflected on all the data available to further refine and develop version 2 of the novel Mediclinic Middle East triage system.

Chapter 8

8 Testing the novel Mediclinic Middle East triage system

This is the final analytical chapter; it describes the final, internally validated version of the novel triage system, tailored through the triage advisory committee process for use in all Mediclinic Middle East emergency centres (ECs). It is based on the data collected throughout this study (Chapters 4 and 7). The committee's fourth meeting resulted in version 2 of the novel triage system. This study evaluates the performance of this novel triage system in relation to its reliability and validity, to determine whether version 2 is suitable for implementation within the four ECs. For this, it was necessary to compare its performance against that of the existing triage systems using the bespoke reference standard (i.e. vignettes) described in chapter 5.

8.1 Aim

The aim of this part of the thesis was to determine whether version 2 of the novel Mediclinic Middle East triage system was reliable and valid compared to the reference standard, and the existing triage systems.

8.2 Objectives

1. To describe the reliability and validity of version 2 of the novel triage system using the bespoke reference standard.

2. To compare the reliability and validity of version 2 of the novel triage system against that of the existing triage systems.

    a. To describe the staff perception on the reliability and validity of the novel triage system. (sub-objective)

8.3 Methods

8.3.1 Study Design

An observational, cross-sectional study was conducted by prospectively evaluating the reliability and validity of version 2 of the novel triage system. The design of this study was similar to what was done in chapter 5, using the same 50 reference standard vignettes. As described in chapter 5, ten vignettes were created for each of the five priority levels of the existing triage systems. For this study, adjustments to the bespoke reference standard were required to fit the four priority levels of version 2 of the novel triage system. It was further necessary to ensure that the reference standard (i.e. vignettes) would be applicable to the new four levels and their definitions, as determined by the triage advisory committee. The vignettes in chapter 5 were designed to serve as a reference standard whereby the four ECs' triage staff's performance would be compared against. They were constructed in such a manner that if any of the existing triage systems were applied, it would result in a similar triage category allocation, but this was done based on their respective five-level definitions.

Version 2 of the novel triage systems' priority designations were based on the tailored early warning scores and clinical descriptors (Chapter 7.A). As a four-level system, it was different than the existing, five-level existing triage systems. For this reason, it was necessary to redistribute the reference standard to accommodate version 2 of the novel triage system. Fundamentally, it was not possible to directly compare triage systems with different outcomes and triage levels. They could, however, be indirectly compared by considering each triage system's performance against the reference standard as the variable; comparing each system's respective performance against the reference standard, instead of the systems themselves. The same expert panel used in chapter 5 was approached to re-evaluate the vignettes based on the parameters of version 2 of the novel triage system. The members of the expert panel were also members of the triage advisory committee and thus were familiar with version 2 of the novel triage system. A consensus approach of review, comment and amendment was used to redistribute the vignettes for the four-level,

version 2 novel triage system in order to create a reference standard by which it could be evaluated (Table 8.1). Once all the experts were in agreement with the priority and triage categories allocated to the vignettes, they were accepted as the reference standard for this study (Appendix H).

Table 8.1 Representation of triage categories and descriptors of version 2 of the novel triage system with the adjusted vignettes (n=50)

Triage Category	Triage descriptor	Adjusted vignettes
		n
1	Resuscitation	4
2	Emergent	18
3	Urgent	13
4	Non-urgent	15

Note: The reference standard in chapter 5 had ten vignettes for each of the five-level categories.

8.3.2 Setting, population and sample size

All registered nurses who perform triage within any of the four ECs were invited to participate, similar to the study in chapter 5. The participants were conveniently sampled as all of them were readily available through the four ECs, as in chapter 5. (130) At the time, approximately 69 registered nurses who regularly practiced triage was employed between the four ECs. It was expected that the majority would agree to participate in the study. As per the study protocol, nursing staff were contacted and invited to participate a month (August 2015) prior to the start of data collection. It was stressed that participation in this study would greatly advance the success of this project, that participation was entirely voluntary, that contributions would be anonymous, and that participation would not have any negative influence on their employment within Mediclinic Middle East. Nurses who agreed to participate in chapter 5 and now also in this study reaffirmed their consent to participate. New volunteers were provided with a participant information sheet (Appendix C). This was followed by the informed consent form (Appendix D) which they agreed to and signed in order to complete registration as a participant.

8.3.3 Data collection

The data were collected using the same online survey platform as in chapter 5: SurveyMonkey (© SurveyMonkey, Palo Alto, CA).(187) Participants received basic orientation material prior to commencement of the study to familiarise themselves with the content, parameters and process of version 2 of the novel triage system (Appendix I). The four EC unit managers, who were also members of the triage advisory committee and reference standard expert panel, provided assistance to the participants by affirming how version 2 of the novel triage system was used. This affirmation assistance was given separate from the reference standard and the unit managers provided no assistance to the participants when they completed the online survey. When evaluating the vignettes, participants were instructed to allocate a relevant triage category based on parameters of version 2 of the novel triage system. A few questions, checked for meaning and consistency by the triage advisory committee, were posed to the participants at the end of the survey to obtain their perception on the performance and application of the novel triage system.

Data collection was conducted over a four-week period from 27 September until 25 October 2015, and will further on be referred to as vignette study two. The surveys were completed under the supervision of the unit managers. They allocated a workstation away from the unit's common area for the surveys to be completed. The unit managers allowed for one participant to complete the survey at a time. Participants were allowed to complete the survey only once and at suitable time during working hours. Participants were instructed to complete the survey alone in one sitting, with each vignette estimated to take a maximum of 2-3 minutes for them to complete. Short rests or bathroom breaks no longer than 10-15 minutes were allowed for participants' comfort and to avoid fatigue. The participants were briefed not to discuss the vignettes during such breaks. Participants were not allowed any other external assistance and their mobile phones were kept, with their permission, by the unit managers during survey completion. At the end of the four-week period (12h00 on 25 October 2015), the survey was closed and data were extracted for analysis.

8.3.4 Variables and bias

The performance of version 2 of the novel triage system was determined through this study, similar to how the existing triage systems were evaluated in chapter 5. In this study, the performance of version 2 of the novel triage system was compared against the performance of the existing triage systems using bespoke reference standard. In imbedding the early warning scores and clinical descriptors to the novel triage system, it made the adjustment and allocation of the reference standard (i.e. vignettes) a fairly objective process as compared to the subjective bias that the existing triage systems inherently brought to this process in chapter 5.

8.3.5 Data analyses

The reliability and validity performance indicators used in chapter 5 were applied to this study so that effective comparisons could be drawn. A confusion matrix (Table 5.3, Chapter 5) was used to analyse sensitivity, specificity, accuracy, diagnostics odds ratio, and over- and under-triage. The latter two were calculated with indicators derived from the confusion matrix. The indicators were included in the results section as they provided the most relevant and pertinent results. Other indicators such as fall-out rates, miss rates, predictive values, false omission rates, false discovery rates, prevalence and likelihood ratios are presented in Appendix J.

Analysis was performed using the latest version of Microsoft Excel (© Microsoft Office, Palo Alto, CA) with a statistical add-in analysis tool from Real Statistics (© Charles Zaiontz, Trento).(186,207) The reliability and validity indicators were described using a 95% confidence interval. The same agreement and association indicators (e.g. Cohens-, Fleiss Kappa and inter-class correlation) from chapter 5 were used to determine the performance of version 2 of the novel triage system. The reliability and validity performances among the four ECs' triage nurses were not compared against each other as they were in chapter 5. This was mainly omitted because the novel triage system's performance was being evaluated and not individual ECs' performances.

8.4 Results

8.4.1 Sample description

Of the 69 potential participants, 54 were enrolled and completed the survey (Table 8.2). Five staff members were unable to participate as they were outside of the United Arab Emirates at the time of data collection and ten others who exercised their right not to enrol for unspecified reasons. There was a total of 2700 completed scenarios and with the vignette reference adjustment this amounted to 216 for triage category one, 972 for triage category two, 702 for triage category three and 810 for triage category four.

Table 8.2 Participant distribution

Total participants available	**69**	
	n	%
Total participant sample	**54**	78.3
Welcare hospital	16	29.6
City hospital	13	24.1
Al Sufouh clinic	16	29.6
Ibn Battuta clinic	9	16.7

8.4.2 Triage category allocations

Triage category allocations by the participants (i.e. raters) were distributed closely around the reference standard (i.e. vignettes) (Table 8.3). Vignettes that were incorrectly triaged mainly received a triage category allocation either one above or one below the reference standard. There were only 6.9% vignettes in category one (i.e. highest acuity) that received a lower triage category allocation. Vignettes in triage categories two and three that were incorrectly triaged mainly received a lower triage category allocation. Vignettes in triage category four (i.e. lowest acuity) that were incorrectly triaged were the only vignettes that received a higher triage category allocation that is noteworthy.

Table 8.3 Overall rater versus reference standard category allocations of vignettes by percent of allocations*

Triage Category		Reference standard			
		1	**2**	**3**	**4**
Raters	**1**	**201 (93.1)**	51 (5.2)	12 (1.7)	2 (0.2)
	2	15 (6.9)	**712 (73.3)**	68 (9.7)	17 (2.1)
	3		170 (17.5)	**421 (60.0)**	121 (14.9)
	4		39 (4.0)	201 (28.6)	**670 (82.7)**
	n	**216**	**972**	**702**	**810**

*, all values are numbers (percent) (i.e. n (%)) of allocations where columns may not add to 100% due to rounding

8.4.3 Validity indicators

Sensitivity of the novel triage system received a very good performance rating for category one and four allocations, and a very good rating for category two and three allocations (Table 8.4). Specificity was high throughout all of the triage categories allocated; they attained a very good performance rating overall. The accuracy for all the triage categories allocated attained a very good performance rating except for triage category three allocations that received a good performance rating. The diagnostic odds ratio is exceptionally high for all the triage category allocations, especially for allocations to triage category one. All these performance indicators show a substantial improvement of the novel triage system's performance over that of the existing triage systems' performances. Over-triage rates were also substantially lower overall. The under-triage rates of the novel triage system exceeded the over-triage rates which was in contrast to the existing triage systems that had higher over-triage rates then under-triage rates. The under-triage rate of triage category three vignettes was the only indicator that performed slightly worse when compared to the under-triage rate of the existing triage systems.

Table 8.4 Sensitivity, specificity, accuracy, diagnostic odds ratio, over-triage and under triage proportions

Triage Category	Novel triage system	Existing triage systems	Triage Category	Novel triage system	Existing triage systems
Sensitivity [a], % (95% CI)			**Specificity** [b], % (95% CI)		
1	93.1 (89.7 – 96.4)	74.7 (71.2 – 78.3)	**1**	97.4 (96.8 – 98.0)	92.2 (91.1 – 93.2)
2	73.3 (70.5 – 76.0)	57.1 (53.1 – 61.1)	**2**	94.2 (93.1 – 95.3)	86.9 (85.5 – 88.2)
3	60.0 (56.3 – 63.6)	47.6 (43.6 – 51.7)	**3**	85.4 (83.9 – 87.0)	83.1 (81.5 – 84.6)
4	82.7 (80.1 – 85.3)	52.2 (38.2 – 46.2)	**4**	87.3 (85.8 – 88.8)	84.2 (82.8 – 85.7)
5		50.0 (46.0 – 54.0)	**5**		96.6 (95.9 – 97.3)
Accuracy, % (95% CI)			**Diagnostic odds ratio**, (95% CI)		
1	97.0 (96.4 – 97.7)	88.7 (87.5 – 89.8)	**1**	498.7 (479.9 – 517.5)	34.8 (33.6 – 36.0)
2	86.7 (85.4 – 87.9)	80.9 (79.5 – 82.3)	**2**	44.6 (42.9 – 46.2)	8.8 (8.5 – 9.1)
3	78.8 (77.3 – 80.4)	76.0 (74.4 – 77.5)	**3**	8.8 (8.5 – 9.1)	4.5 (4.3 – 4.6)
4	85.9 (84.6 – 87.2)	75.8 (74.3 – 77.4)	**4**	32.9 (31.7 – 34.1)	3.9 (3.8 – 4.0)
5		87.3 (86.1 – 88.5)	**5**		28.5 (27.5 – 29.5)
Over-triage [c], % (95% CI)			**Under-triage** [d], % (95% CI)		
2	5.2 (3.4 – 7.0)	26.1 (22.6 – 29.6)	**1**	6.9 (4.9 – 8.9)	25.3 (21.8 – 28.8)
3	11.4 (8.8 – 14.0)	27.1 (23.5 – 30.7)	**2**	21.5 (18.2 – 24.8)	16.8 (13.8 – 19.8)
4	17.3 (14.2 – 20.4)	47.3 (43.3 – 13.0)	**3**	28.6 (25.0 – 32.2)	25.3 (21.8 – 28.8)
5		50.0 (46.0 – 54.0)	**4**		10.5 (8.0 – 13.0)

CI, confidence interval; a, vignettes triaged correctly by the raters amongst all the true vignettes as determined by the experts; b, vignettes triaged correctly by the raters amongst all the untrue vignettes as determined by the experts;

8.4.4 Agreement and association indicators

The same agreement and association indicators that were found relevant to describe the reliability of the existing triage systems in chapter 5 are presented to describe version 2 of the novel triage system and provide for comparison (Table 8.5). The overall agreement between the raters and the experts per triage category shows almost perfect for category one, substantial for categories two and four, and moderate for category three allocations. The overall agreement between the raters and the experts for all the triage categories shows an unweighted estimation of substantial agreement, a linear weighted estimation of substantial agreement, and quadratically weighted estimation of almost perfect agreement. The overall inter-rater agreement as estimated through Fleiss Kappa shows only moderate agreement between the raters. The inter-class correlation shows substantial association between the raters in this study and is similar to the findings in chapter 5.

Table 8.5 Agreement and association between the raters and the reference standard (i.e. vignettes), inter-rater and inter-class

Triage Category	Novel triage system	Existing triage systems
Agreement between the raters and the reference standard per triage category (Cohen's Kappa), (95% CI)		
1	0.82 (0.78 – 0.86)	0.65 (0.62 – 0.69)
2	0.70 (0.67 – 0.73)	0.42 (0.38 – 0.46)
3	0.45 (0.41 – 0.49)	0.29 (0.25 – 0.33)
4	0.68 (0.65 – 0.71)	0.26 (0.22 – 0.30)
5		0.54 (0.50 – 0.58)
Agreement between the raters and the reference standard for all triage categories (Cohen's Kappa), (95% CI)		
Unweighted	0.64 (0.62 – 0.66)	0.43 (0.41 – 0.45)
Linear	0.74 (0.72 – 0.76)	0.67 (0.65 – 0.68)
Quadratic	0.83 (0.81 – 0.84)	0.83 (0.81 – 0.84)
Agreement between the raters (Fleiss Kappa), (95% CI)		
Inter-rater	0.54 (0.53 – 0.54)	0.35 (0.34 – 0.35)
Associative correlation between the raters, (95% CI)		
Inter-class	0.78 (0.71 – 0.85)	0.77 (0.70 – 0.84)

CI, confidence interval

8.4.5 Participant evaluation of the novel triage system

The participants were able to give basic feedback based on four questions to determine their perception of the performance and application of the novel triage system (Table 8.6). The majority of participants understood how the novel triage system worked, with only one participant not understanding at all. More than half the participants felt that the novel triage system made it easier for them to triage cases however, a fifth of the participants did not share that feeling. The participants were predominantly positive on the ease of which they could use the novel triage system. Half of the participants felt that the novel triage system would be better to use in the future with a third of the participants being unsure.

Table 8.6 Participant evaluation of the novel triage system (n=54)

Did you understand how the new Mediclinic Middle East triage system works?		
	n	**%**
Yes, completely	38	70.4
Just a little	15	27.8
Not at all	1	1.9
Did the new Mediclinic Middle East triage system make it easier for you to triage cases?		
	54	
Yes	28	51.9
Maybe	15	27.8
No	11	20.4
How easy or difficult did you find the use of the new Mediclinic Middle East triage system?		
	54	
Very easy	2	3.7
Easy	22	40.7
Neither	19	35.2
Difficult	10	18.5
Very difficult	1	1.9

Would this new Mediclinic Middle East triage system be better to use in the future?		
	54	
Yes	25	46.3
Maybe	17	31.5
No	12	22.2

8.5 Discussion

Version 2 of the novel triage system showed substantially better performance against the reference standard than the performance of the existing triage systems against the reference standard (Table 8.4). The sensitivity of version 2 of the novel triage system increased from good to very good in category one vignettes, with the most substantial increase of all the other triage categories from only a moderate performance in chapter 5 to a good to very good performance in this study. The specificity of version 2 of the novel triage system has also risen slightly but remains on the same overall performance level of very good as compared to the existing triage systems. Although sensitivity reflects the ruling-out of acuity presentations associated with triage categories, there has been no subsequent decrease in specificity which is measured that reflects ruling-in criteria. This demonstrates that version 2 of the novel triage system has improved its ruling-out ability without losing its ruling-in ability, thus moving to a scenario where triage is more accurate. This is substantiated by the improved accuracy performance and overwhelming increase of the diagnostic odds ratio indicating that version 2 of the novel triage system is superior at correctly discriminating between triage category allocations. This is indicated in the accuracy of category one and two allocations that improved more than 5% each, and the diagnostic odds ratio showing these two category allocations had more than a fivefold improvement.

The triage category allocations of version 2 of the novel triage system, although showing the same clustering that was observed with the existing triage systems, the clusters are tighter around the correct triage category as determined by the

reference standard. Where triage categories were rated incorrectly by the participants, there was a tendency to under-triage as compared to the over-triage tendency of the existing triage systems. Over-triage rates decreased substantially as the novel triage system performed more accurately, which is an expected relationship.(24,62,69,77) The under-triage of category one allocations substantially decreased, however, the rates associated with the other categories remained fairly similar to slightly elevated as compared to the existing triage systems. This shows the importance and relationship of having high specificity within triage as an increased safety will create over-triage, however, an increased sensitivity and accuracy will in turn also result in higher under-triage rates, as found in this study. It is important to have a highly sensitive and specific triage system, however, a fine balance needs to be maintained to not only reduce inaccuracy but to keep the triage system allocations within safe limits. The ultimate goal would be to have no cases of over-triage or under-triage, however, the uncontrollable factors involved within ECs (i.e. patient volumes and presentations, triage nurse subjectivity and error, resource availability, etc.) would make such absolutes near impossible. Although the goal would be perfection, the realistic approach is to determine what is reasonably acceptable and to ensure that patients' safety is taken into consideration. The higher under-triage rate than the over-triage rate may also be the result of the combination of acuity levels four and five from the existing triage systems to the novel triage system. The definitions of the categories have thus changed to support the overwhelming low acuity patient population without sacrificing the identification potential of the life-threatening high acuity. Further refinement will be needed to reduce under-triage without sacrificing the accuracy of the triage system. Under-triage rates vary greatly between triage categories (Table 2.7, Chapter 2) as found within similar studies and indicate that no absolute standard exists.(24,62,69,77) It is accepted that under-triaging high acuity cases imposes a greater risk than it does low acuity cases. The findings of this study show that although under-triage can be considered high, version 2 of the novel triage system has greatly reduced the under-triage rate of high acuity cases as compared to the existing triage systems. This indicates that version 2 of the novel triage system is not only more accurate for low acuity cases but is also less risky for high acuity cases.

It was expected that overall inter-rater agreement would increase due to all the participants using the same version 2 of the novel triage system. Previously, in chapter 5, the participants were using different triage systems, specific to each EC (Table 8.5). Overall agreement between the participants and the reference standard increased across all the triage categories with substantial to almost perfect agreement in some instances. Although the agreement between the participants and the reference standard of category three allocations increased substantially, its agreement performance remains the lowest among all the categories. Across all the performance measures in this study category three vignettes performed the worst in all aspects from sensitivity, specificity, accuracy, diagnostic odds ratio and agreement. This indicates that acuity levels of this nature (i.e. in-between high and low) are the most complex triage category for triage nurses to allocate, in this environment. The complexity of such cases may induce uncertainty among triage nurses as to the correct triage category to allocate. This finding may be unique to the Mediclinic Middle East EC environment, as this was not found in other similar studies; thus further investigation and study into triage category three allocations is needed. (18,24,55,62,69,77,80,117) A lot can be lost when evaluating a triage system using an objective test. Certain biases can also contribute to a performance measurement that can be removed during a real world testing. Developing further bespoke training and validation programs may aid in the understanding and application of the novel triage system during its implementation within Mediclinic Middle East ECs. Although triage category three was an outlying result, the indicators show that version 2 of the novel triage system performed better in discriminating this complex acuity level above that of the existing triage systems.

The inter-rater agreement increased from a fair to a moderate performance, which indicates that the participants had a more like-minded approach to their triage category allocations. This provides confidence in version 2 of the novel triage system that participants allocated the same triage category to the same vignettes. Although the reference standard between this study and that used in chapter 5 did have some variation, the correlation between the rater groups remained identical. This indicates that there was no variation in the participants' population groups and provides

confidence that the comparisons made between version 2 of the novel triage system and the existing triage systems are true and dependable.

Even though the participants only received basic orientation on the novel triage system it appeared that they understood how it worked and found it reasonably easy to use (Table 8.6). The increased performance of version 2 of the novel triage system over the existing triage systems had been substantial with the limited training the participants received in this version 2 of the novel system was considered. It is assumed that the design of the novel triage system made it easier to use and understand through the introduction of objective measures like early warning scores. The novel triage system therefore allowed for a more objective approach to the triage of patients by introducing a safety mechanism where triage is not solely a subjective decision made by triage nurses.

8.5.1 Limitations

Similar limitations applied to those found in chapter 5. The same steps were taken to reduce or eliminate potential bias from either the reference standard or the participants themselves. The timeframe for data collection for this study was four weeks as compared to the two-week period in chapter 5. This adjustment was due to operational access for the participants to complete the survey, and the time needed for the participants to orientate themselves to version 2 of the novel triage system. It was anticipated that the participants would require some time to work through the orientation materials and to make sure they understood how version 2 of the novel triage system is applied, therefore an extended data collection time was allowed to ensure that the data collected was trustworthy.

A re-evaluation of the vignette reference standard was necessary to be compatible with version 2 of the novel triage systems descriptions, purpose and outcomes. With the expert panel consisting of members of the triage advisory committee it was easy for them to grasp how the reference standard needed to be changed. Using version 2 of the novel triage system they were able to objectively re-allocate the reference

standard categories of the 50 vignettes. By doing this reference standard adjustment, it became clear that the performance measures of the existing triage systems could not be directly compared to that of version 2 of the novel triage system. An indirect approach was taken to compare how the triage systems performed against the reference standard, and thus by having the most accurate reference standard that suited the existing triage systems and version 2 of the novel triage system, respectively, an accurate comparison could be made on this basis. The associated correlation found between the two studies were identical. This indicated that the reference standard was appropriate in both studies as well as for the participant populations and could thus be confidently compared.

8.6 Chapter summary

This study has shown that version 2 of the novel triage system is more suitable to the Mediclinic Middle East EC environment than the existing triage systems. When compared to the reference standard, version 2 of the novel triage system outperformed the existing triage systems in all aspects of evaluation. Version 2 of the novel triage system proved to be more reliable and valid when applied to the bespoke reference standard, and indirectly the patient population within Mediclinic Middle East ECs. This study was able to provide insight into staff perception on the reliability and validity of the novel triage system. It showed that version 2 of the novel triage system proved to be more objective and easier to use than the existing triage systems, and substantiated the standardisation thereof throughout all four Mediclinic Middle East ECs.

Chapter 8.A

8.A Confirm the novel Mediclinic Middle East triage system

The study conducted in chapter 8 established the reliability and validity of version 2 of the novel triage system and compared its performance to those of the existing triage systems established in chapter 5. This chapter signifies the final reflective period of the third iteration (Figure 3.3, Chapter 3) of the action research process of this project. Following the performance evaluation of version 2 of the novel triage system, the triage advisory committee needed to confirm whether this version was ready for implementation and what further steps should be taken.

8.A.1 Fifth triage advisory committee meeting

The fifth triage advisory committee meeting (Box 8.1) was held on 15 of November 2015 and was attended by seven committee members. This was the final meeting in the scope of this project and resulted in project finalisation and acceptance of version 2 of the novel triage system (Chapter 7.A) to be implemented within the four Mediclinic Middle East ECs. The final novel Mediclinic Middle East triage system is presented in Appendix I.

Box 8.1 Fifth triage advisory committee meeting's minutes

Purpose

- To present and evaluate the findings of the phase five [Chapter 8] data.
- To conclude the scope of this project by confirming an implementable version of the novel triage system.

Main outcomes

- The committee is satisfied with the findings made during the phase five [Chapter 8] data collection which indicated that version 2 of the novel triage system outperforms the existing triage systems within the Mediclinic Middle East EC environment.

- The committee confirmed that the application of the early warning scores and the descriptors by the nursing staff is a new concept that is prone to have initial problems.
- The committee agrees that version 2 of the novel triage system is not yet perfect, but it is a much better triage approach than what is currently being used within the four ECs.
- The committee agrees that the developed novel Mediclinic Middle East triage system addresses the two aims previously set by this committee in that it aids in the detection and treatment of critically ill patients quickly, and that it aids in the improvement of the flow of patients through the EC.
- The committee decided that version 2 of the novel Mediclinic Middle East triage system is ready to be implemented throughout the four ECs in its current form with the agreed time-to-physician targets [Tables 7.11, 7.12, 7.13, 7.14, Chapter 7.1].

Action points

- The committee requests the researcher to aid in the transition of this project to the implementation of the novel Mediclinic Middle East triage system throughout the four ECs.
- Further investigation within Mediclinic Middle East structures will be conducted to determine a suitable date for implementation and what steps would be necessary in terms of training and administration to make the transition from the existing triage systems to the novel triage system possible.

EC, emergency centre; all wording in brackets, e.g. [Chapter 8], has been added for reporting purposes in this thesis

8.A.2 Chapter summary

The triage advisory committee confirmed that the evidence provided in this project has attributed substantially to the development and design of a novel triage system tailored to the Mediclinic Middle East EC environment. The committee was satisfied with the reliability and validity performance of version 2 of the novel triage system. As the endpoint for this research project is reached it has been successful in establishing a novel triage system that is reliable and valid. This novel triage system has shown to be safe for implementation within Mediclinic Middle East ECs.

Chapter 9

9 Conclusion

In triage, high value is placed on the reliability (i.e. coming up with the same answer) and validity (i.e. coming up with the right answer) of the triage system used to ensure that safe and efficient priority is allocated appropriately within an emergency centre (EC).(23–27,39–42,55,62,64,70,74,80,83,85,87,91,92,202) To sufficiently examine the attributes of a triage system, the following is required: knowledge of the inherent patient cohort it is to be used on, the environment it is to be used in, the providers it is to be used by, and how it is to be utilised on a day-to-day basis. This thesis aimed to investigate the reliability and validity of existing triage systems within Mediclinic Middle east ECs, and then to use these triage systems as a starting point to design, standardise and validate a single, locally appropriate triage system. As it turns out, this required design of a bespoke, novel triage system. In developing this novel triage system for Mediclinic Middle East the goal was to ensure that the eventual triage categories within the system would accurately and safely assign priority to adults and children within its four ECs. Using a business and healthcare improvement model (i.e. Systems Development Life Cycle), through an action research process, the existing triage process was first described and later used to create the novel triage system and internally validate its performance.

This thesis made a number of findings that have not previously been described in any private hospital group in the United Arab Emirates, or the Middle East. Firstly, it was found that Mediclinic Middle East ECs experience large volumes of low acuity patients; high acuity patients were the exception. Secondly, the use of multiple triage systems between and within facilities, either exclusively or in combination, was not ideal within a single hospital group that cross-referred patients. This was shown to have negative effects on the overall triage performance and could have led to unnecessary complications and possible patient safety concerns. Thirdly, it could not be assumed that if a triage system works elsewhere in the world, it would work in every environment, for example, the Middle East. This was shown to be the case within the Mediclinic Middle East setting and necessitated the development of a

novel triage system. It was concluded through a consensus process that a four-level triage system that combines early warning scores and clinical descriptors was the best triage fit for Mediclinic Middle East's ECs. Subsequent modelling showed that this novel triage system was more reliable and valid within the local environment, than the other existing triage systems Mediclinic Middle East had been using.

9.1 Mediclinic Middle East emergency centre profile

It was shown in chapter 4 and again in chapter 7 that the four ECs attend to small patient numbers on a day-to-day basis when compared to the patient numbers from public ECs in the region.(6,7) Furthermore, the two clinic ECs attended to nearly five times fewer patients than the two hospital ECs. Local government regulations that prevents private healthcare facilities from attending to major trauma were reflected in the presenting illness profile, which predominantly related to non-traumatic presentations (Tables 4.4 and 7.4).(8–10) It was evident from the triage category allocations coupled with the diagnosis profile, that the four ECs experienced predominantly low acuity patient presentations and that high acuity patient presentations were the exception (Tables 4.5, 7.5 and Figures 4.2, 7.2). The use of various triage systems (i.e. the Canadian Triage and Acuity Scale, the Manchester Triage System and the Emergency Severity Index) within a single organisational structure in some cases the same facility was shown to be, and later considered, less than optimal. These findings were the first to prompt the need for a single, bespoke, standardised triage system for Mediclinic Middle East ECs.

9.2 Reliability and validity of existing triage systems

Of the three existing triage system, the Canadian Triage and Acuity Scale was mostly used by the four ECs (Table 5.9) (Chapter 5). The overall reliability and validity performance of these triage systems was moderate. It showed low sensitivity in the categories up to the highest acuity level, and high under-triage of the highest acuity level (Table 5.13). It was inferred that the existing triage systems were not sufficiently accurate in determining priorities, even suggesting a potentially harmful practice. Inter-rater agreement within and between the four ECs reached moderate

agreement, confirming that combining various triage systems between and within ECs was not ideal (Table 5.14). These findings suggested that the existing triage systems were not suitable and along with the findings from chapter 4, the Mediclinic Middle East triage advisory committee decided that a more objective triage system was needed. One that would more specifically meet the needs of the organisation's local environment.

During development, the Mediclinic Middle East triage advisory committee expressed two goals (Chapter 6): the first, to detect and treat critically ill patients quickly, and the second, to improve the flow of patients through the ECs by means of triage. The term flow broadly referred to EC timeframes, treatment regimes, patient streaming and experience. It was acknowledged that an effective triage system would indirectly affect these variables and be additional cause for a successful triage system's validation. In chapter 7, EC flow was evaluated and it was found that overall, time-to-physician for all triage categories were reasonably good and corresponded to international triage system standards (Table 7.8).(56–59) This was hardly surprising given the low acuity, low volume of patients attended to at the four ECs. There were, however, subtle differences between priorities (specifically the top and bottom priorities) and as triage is not just about prioritising care, but also resources, triage was still felt to be an important part of EC operation. It was also considered that the existing triage systems were less adept at differentiating priority in the ECs' lower acuity cohort. Better differentiation using a simplified triage system, would in all likelihood result in better prioritising and subsequent care and resource allocation downstream.

9.3 Best-fit novel triage system development and evaluation

Following evaluation of the data presented from chapters 4 through 6, the triage advisory committee concluded that none of the existing triage systems could be exclusively used. Taking into account local government regulations and the overwhelming support for a simplified triage system by the Mediclinic Middle East triage advisory committee, it was decided to develop a bespoke triage system. This

novel system would employ the use of an early warning score as well as clinical descriptors. These early warning scores were already in use within the hospitals and would create better continuation of care should a patient require admission.(11) The details of the novel triage system were directly informed by the content of the existing triage systems. The ECs' acuity profiles allowed for the combination of triage categories one and two, and four and five. Category one and two hardly had any difference in terms of the efficiency of care provided. This was due to favourable patient staffing ratios which could only be expected from a private facility. However, due to medico-legal, audit and government reporting reasons, it was decided to keep triage categories one and two separate and only combine categories four and five, to create a four-level triage system. As category one cases occurred fairly infrequently, day-to-day operations would in essence deal with mainly three triage categories anyway (i.e. categories two, three and four).

Version 1 of this novel triage system was established after the third triage advisory committee meeting described in chapter 6 (Tables 6.1 and 6.2). After this meeting, additional data was gathered for system refinement and this is described in chapter 7. Chapter 7 also provided information relating to vital parameters, descriptor use and EC timeframes. These were used to refine the novel triage system and establish version 2 during the fourth triage advisory committee meeting outlined in chapter 7.A (Tables 7.11 to 7.14). The layout and construct of the novel triage system resembles that of the South African Triage Scale, with parallel use of early warning scores and clinical descriptors. Although the South African Triage Scale was used in the past within one of the ECs, this development was not intentional but a product of the local triage requirements. The reason why this system was removed from operational use is unknown. Findings from this project, however, suggest that the South African Triage Scale could possibly have been the best triage system to use in the past, within the Mediclinic Middle East EC environment.

The reliability and validity of this novel triage system were experimentally evaluated in chapter 8 and could be indirectly compared to the performance of the existing triage systems through the use of the previously established, slightly adapted

reference standard (i.e. vignettes). A substantial improvement was observed in the performance of the novel triage system over that of the existing triage systems. Sensitivity increased substantially throughout all the triage categories and over-triage rate decreased in equal measure (Table 8.4). Although the overall under-triage rate remained fairly similar, there was a substantial decrease in under-triage of triage category one cases, suggesting the novel system was safer triage system for high acuity presentations. The increased performance markers of the novel triage system over the existing triage systems were further demonstrated with an increased inter-rater reliability from moderate to substantial, and almost perfect in some triage categories. At the final triage advisory committee meeting, members were unanimous in the decision that the novel triage system (Appendix I) had proved to be more reliable and valid within the Mediclinic Middle East EC environment and should therefore be implemented within all the ECs.

9.4 Recommendations and further research

Although the objectives of this thesis were addressed, there were several findings that should be further researched to continue triage service improvement at Mediclinic Middle East ECs and perhaps even wider in the Middle East. The recommendations and further research, as instigated from this thesis are outlined below.

1. Validation of the novel triage system is required following the operational implementation of the system within the four ECs. This step of systems development follows directly from this thesis in that an appropriate novel triage system was designed and found ready for implementation within real-world settings.

2. The novel triage system was developed and designed for use in the specific Mediclinic Middle East EC environment, however, its approach to triage within low acuity EC settings can be transposed to similar environments within the United Arab Emirates, the Middle East or elsewhere in the world where such conditions

exist. Further testing and real-world validation of the novel triage system is required within similar patient demographic environments, for example, other private healthcare facilities within the United Arab Emirates. This testing can also be further expanded to evaluate whether the novel triage system could be applicable to even broader, low acuity environments.

3. Ongoing audit of the novel triage systems' reliability and validity performance needs to be done to instil a pattern of reliance and confidence in the system. Such continued evaluation may indicate possible changes that need to be made to the system for refinement to its environment.

4. Continued audit and evaluation of the Mediclinic Middle East EC patient demographic needs to occur as the snapshot in time taken by this study may change with changing population dynamics and governmental regulations. Naturally this may affect the triage system too.

5. Further qualitative research is needed from a triage system provider and user's perspective. Staff training, experience, interaction and adherence to the novel system needs to be more extensively evaluated as this may have indirect effects on the success of the triage system. Understanding these perceptions better, may ultimately assist with further design changes to the triage system.

6. With such a diverse staff cohort, resident perceptions surrounding emergency care, personal and cultural expectations need to be qualitatively detailed in order to further optimise the quality of the service provision.

7. It would also be interesting to see what triage systems are in use (if any) and how triage is applied within the public sector, as well as how this differs from the substantial private sector presence in the region. Given the cultural differences, perhaps a bespoke system, or purpose-driven adaptation of an existing triage system is needed in the region as is the case in Africa with the South African Triage Scale.

8. It is clear that the work done for Mediclinic Middle East is just the tip of the triage iceberg. With only a handful of published papers on triage in the region, this is a research opportunity that can have significant safety and quality improvement implications.

9.5 Project conclusion

When considering triage, it is important to understand the environment in which a system will be applied. Mediclinic Middle East found that the application of various triage systems within their EC operations affected quality and opened up possible risks to patient safety. It was the aim of this thesis to study the reliability and validity of existing triage systems within Mediclinic Middle East ECs, and then to use these triage systems as a starting point to design, standardise and validate a single, locally appropriate triage system. This thesis found that their EC environments studies catered for distinctively low acuity cases which was poorly differentiated and prioritised by the existing triage systems. Through a unique application of systems development and an action research process, a novel four-level triage system that incorporates early warning scores and clinical descriptors was created, tested experimentally and accepted through consensus as a best-fit for the Mediclinic Middle East EC environment. Further work is required in the organisation to validate the system in a real-world setting, as well as the region to address the paucity in triage research.

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Appendices

Appendix A: 50 vignettes – chapter 5

Triage Case Category: **PRIORITY 1 - RESUSCITATION** Time to Physician: **IMMEDIATE - 0 MINUTES**																	
CASE #	**Time**	**Age**	**Gender**	**Chief Complaint**	**Signs & Symptoms**	**History**	**T/M**	**LOC**	**Mobility**	**RR** *p/min*	**HR** *p/min*	**SBP** *mmHg*	**DBP** *mmHg*	**Temp** *°C*	**SpO_2** *%*	**Pain** */10*	**HGT** *mmol*
1	8:00	65	Male	Chest pain	Pale, profuse sweating, difficulty breathing	Chest pain started 40min ago, patient suffering from angina	Medical	Reacts to pain	Stretcher	30	145	150	110	37	90	9	3,5
2	14:00	85	Female	Severe abdominal and back pain	Signs of Shock, pulsating abdominal masses	Sudden onset	Medical	Confused	Wheelchair	32	120	80	60	37	92	10	5,4
3	3:00	25	Male	Unresponsive	Pale, cold, vomit in mouth, smell of alcohol	Excessive alcohol consumption	Medical	Unresponsive	Stretcher	8	160	120	80	36	85	n/a	3,4
4	21:00	6	Male	Severe shortness of breath	Difficulty breathing, stridor, drooling, hoarse voice	Fever	Medical	Irritable	Wheelchair	30	130	115	75	39	85	n/a	n/a
5	18:00	2	Female	Active Seizures	Active tonic-clonic convulsions	Fever	Medical	Unresponsive	Abnormal for age	0	180	n/a	n/a	40	70	n/a	n/a
6	19:00	35	Female	Severe shortness of breath	Hives, flushed skin, swollen face/body/extremities	Exotic seafood dinner	Medical	Reacts to pain	Stretcher	8	140	75	60	37	90	n/a	4,4
7	16:00	47	Female	Unresponsive	Pale, drooling from mouth	Insulin dependant diabetic	Medical	Unresponsive	Stretcher	6	145	95	70	37	85	n/a	0,4
8	1:00	1	Male	Severe shortness of breath	Wheezing, pale, poor response	Previous admission for severe bronchiolitis	Medical	Reacts to pain	Abnormal for age	48	140	90	65	37	70	n/a	4,7
9	17:00	72	Male	Unresponsive	Unresponsive	Unknown	Medical	Unresponsive	Stretcher	0	0	n/a	n/a	n/a	n/a	n/a	n/a
10	23:00	28	Female	Poor responsiveness	Pale, decreased response, gasping respirations	Known anti-depressant use	Medical	Reacts to pain	Stretcher	6	145	150	100	37	86	n/a	1,4

Triage Case Category: **PRIORITY 2 - EMERGENT** Time to Physician: **15 - 30 MINUTES**

CASE #	Time	Age	Gender	Chief Complaint	Signs & Symptoms	History	T/M	LOC	Mobility	RR	HR	SBP	DBP	Temp	SpO_2	Pain	HGT
										p/min	*p/min*	*mmHg*	*mmHg*	*°C*	*%*	*/10*	*mmol*
1	15:00	82	Female	Sudden Collapse	Left sided paralysis, slurred speech, facial droop	Hypertension, cholesterol problems, diabetic	Medical	Confused	Wheelchair	10	140	155	115	37	95	5	4,8
2	13:00	35	Male	Headache	Severe headache, tingling sensation in hands and feet, loss of memory	Fell from 2m scaffolding and hit his head about 2 hours ago	Trauma	Confused	Wheelchair	12	110	90	70	37	97	9	5,6
3	19:00	47	Female	Dizziness	Shortness of breath, pallor, light-headedness	Hypertension, depression	Medical	Confused	Wheelchair	8	30	85	60	37	90	0	4,8
4	9:00	55	Male	Palpitations	Shortness of breath, pallor, light-headedness	Tachycardia	Medical	Alert	Wheelchair	24	135	135	95	37	95	1	4,9
5	4:00	3	Male	Rashes and fever	Drooling, no wet diapers	Onset of hives a few hours ago	Medical	Reacts to voice	Abnormal for age	30	90	110	70	39	94	2	5
6	18:00	28	Male	Altered mental status	Pale, cool, sweaty	Diabetic, no food or drink taken since morning, forgot insulin	Medical	Confused	Wheelchair	10	125	120	85	37	96	0	2
7	23:00	6	Female	Difficulty breathing	Moderate stridor, hoarse voice, anxious, tripod posture	Fever the last few days	Medical	Alert	Walking	14	135	115	80	39,5	94	4	3,4
8	21:00	2	Female	Diarrhea	Severe weakness, cold, pale, bloody stool	Diarrhea started 2 days ago, no eating and drinking since then	Medical	Reacts to voice	Abnormal for Age	24	135	100	65	37	96	n/a	2,3
9	14:00	32	Female	Abdominal Cramps	Active labour, severe abdominal pain	First pregnancy, full term	Medical	Alert	Stretcher	20	135	160	110	37,5	95	10	5,8
10	6:00	68	Male	Chest pain	Central chest pain radiating to left arm and jaw	Hypertension, cholesterol problems, pain for the last 45min	Medical	Alert	Wheelchair	25	125	130	95	37	96	6	4,2

Triage Case Category: **PRIORITY 3 - URGENT** Time to Physician: **30 - 60 MINUTES**

CASE #	Time	Age	Gender	Chief Complaint	Signs & Symptoms	History	T/M	LOC	Mobility	RR	HR	SBP	DBP	Temp	SpO_2	Pain	HGT
										p/min	*p/min*	*mmHg*	*mmHg*	*°C*	*%*	*/10*	*mmol*
1	12:00	37	Male	Abdominal Pain	Constipation, poor appetite, nausea	Pain has increased over the last day, no bowel movements in 24h	Medical	Alert	Walking	16	120	110	90	35,5	98	2	4,7
2	17:00	22	Male	Tiredness	Dry skin, headache, thirst	Worked construction in the sun the whole day with poor water consumption	Medical	Confused	Walking	10	110	115	90	37	99	1	4,1
3	14:00	56	Female	Anxiety	Emotional distress, extreme anxiety, palpitations	Erratic behaviour after receiving news of death in the family	Medical	Alert	Walking	30	120	135	90	37	98	0	5,6
4	15:00	4	Female	Asthma	Speaking in sentances, coughing, wheezing on auscultation	Known asthmatic, attack occurred during a sandstorm	Medical	Alert	Walking	30	125	110	70	37	94	0	4,7
5	10:00	85	Female	Lower back pain	Sudden onset, numbness and tingling in legs	Slipped and fell on wet floor	Trauma	Alert	Wheelchair	14	120	140	85	37	99	7	5,6
6	5:00	27	Male	Breathing difficulty	Pain increasing with movement or breathing, mild crackles, productive cough	Upper respiratory tract infection 1 week ago	Medical	Alert	Walking	25	120	120	80	38	94	3	6,1
7	2:00	1	Male	Fever	Irritable, flushed skin, loss of apatite	Symptoms began the previous day	Medical	Reacts to pain	Normal for Age	35	120	100	60	39,5	96	n/a	4,8
8	16:00	8	Female	Right arm pain	Tenderness, bruising, swelling, redness on right arm	Fell of swing at school	Trauma	Alert	Wheelchair	24	115	120	75	37	99	7	5,2
9	11:00	44	Male	Left leg pain	Headache, puss draining and red streaking away from wound	Untreated open wound injury from motorbike accident 4 days ago	Trauma	Alert	Wheelchair	16	125	140	95	37,6	99	4	5,3
10	21:00	36	Female	Seizures	Dizziness, tired feeling, abnormal behaviour	Known epileptic, seizure episode 1h ago	Medical	Confused	Wheelchair	12	110	135	80	37	98	0	4,2

Triage Case Category: **PRIORITY 4 - LESS URGENT** Time to Physician: **60 - 120 MINUTES**

CASE #	Time	Age	Gender	Chief Complaint	Signs & Symptoms	History	T/M	LOC	Mobility	RR	HR	SBP	DBP	Temp	SpO_2	Pain	HGT
										p/min	*p/min*	*mmHg*	*mmHg*	*°C*	*%*	*/10*	*mmol*
1	14:00	10	Female	Jellyfish sting	Redness and pain over legs	Received stings whilst swimming at the beach	Trauma	Alert	Walking	20	100	120	75	37	99	2	5,6
2	11:00	24	Male	Burn on left forearm	Redness over left forearm 4cm wide	Accidentally stood with arm against hot pipe at work	Trauma	Alert	Walking	10	85	120	80	37	99	2	4,9
3	19:00	3	Female	Foreign Body Ingestion	Nausea, no airway compromise	Child admits to ingesting small round toy	Trauma	Alert	Walking	20	95	105	70	37	98	3	5,4
4	13:00	54	Female	Left ear pain	Loss of hearing in left ear	Pain started 3 days ago and is getting worse	Medical	Alert	Walking	12	110	130	75	37	99	4	5,8
5	16:00	46	Male	Eye irritation	Small blood vessel rupture in sclera, persistent itching, redness and burning sensation	Wooden splinter was self removed about 4h ago	Trauma	Alert	Walking	12	85	130	90	37	98	3	5,6
6	8:00	88	Female	Feeding tube problems	Feeding tube has fallen out	Accidentally pulled out feeding tube in bathroom	Medical	Alert	Wheelchair	16	95	145	95	37	97	3	3,6
7	14:00	33	Male	Nosebleed	Intermittent nosebleed	Recent nasal surgery	Medical	Alert	Walking	12	110	125	85	37	98	2	4,9
8	10:00	18	Female	Vaginal bleeding	Cramps interferes with daily activity, bleeding for more than 10 days	Regular menstrual cycle, first time this has happened	Medical	Alert	Wheelchair	16	85	110	70	37	99	4	5,7
9	5:00	29	Male	Hives	Mild swelling of extremities, diarrhea, moderate discomfort	New onset of hives after camping trip	Medical	Alert	Walking	10	75	125	85	37	99	2	4,7
10	7:00	38	Male	Abdominal pain	Blood in urine, nausea and vomiting	Pain started 2 days ago and is getting worse	Medical	Alert	Walking	14	90	120	85	37,5	99	5	4,7

Triage Case Category: **PRIORITY 5 - NON-URGENT** Time to Physician: **120 OR MORE MINUTES**

CASE #	Time	Age	Gender	Chief Complaint	Signs & Symptoms	History	T/M	LOC	Mobility	RR	HR	SBP	DBP	Temp	SpO_2	Pain	HGT
										p/min	*p/min*	*mmHg*	*mmHg*	*°C*	*%*	*/10*	*mmol*
1	12:00	18	Male	Abdominal Pain	Indigestion, bloating, loss of appetite	Unusually frequent bowl movements the last few days	Medical	Alert	Walking	12	80	125	85	37	99	1	4,6
2	16:00	50	Male	Back Pain	Minor discomfort to lower back	Chronic back problems	Medical	Alert	Walking	12	95	135	90	37	99	2	5,4
3	7:00	5	Female	Coughing	Productive cough	Coughing and runny nose started night before	Medical	Alert	Walking	20	85	105	70	37	99	0	5,1
4	20:00	24	Male	Chest Pain	Tenderness when palpation over the right pectoral muscle	Football hit to the right chest during a training session	Trauma	Alert	Walking	14	75	120	85	37	99	2	6,2
5	11:00	36	Female	Diarrhea	Diarrhea and loose stools 4 times in last 24h	Consumption of spicy food the previous evening	Medical	Alert	Walking	12	95	110	85	37	99	0	4,8
6	17:00	40	Female	Sunburn	Feeling flushed and warm, redness over body	Sunbathing at the beach for 2 to 3h	Trauma	Alert	Walking	12	85	115	75	37	99	2	6
7	12:00	2	Female	Scrapes and bruises	Minor scrapes and bruises over legs and hands	During playtime at school ran into the bushes and fell down	Trauma	Alert	Walking	30	120	100	65	37	99	2	4,5
8	8:00	34	Male	Sore Throat	Dry cough and scratchy throat	Up late at a concert the night before	Medical	Alert	Walking	10	90	130	90	37	99	2	5,2
9	15:00	62	Male	Nasal Congestion	Sneezing and mild cough, sore throat, nasal discharge	Grandchild has been ill the last few days as well	Medical	Alert	Walking	12	95	140	95	37	99	0	5,1
10	13:00	70	Female	Tongue problems	Sore spots and discoloration of tongue	Heavy smoker	Medical	Alert	Walking	12	85	135	100	37	99	0	5,6

Appendix B: research information sheet

RESEARCH INFORMATION SHEET

Standardisation, validation and implementation of a triage system in a private hospital group in the United Arab Emirates

(Principal Researcher: Enrico Dippenaar, Study Number: EM2014/11, HREC Ref: 744/2014)

WE WOULD LIKE TO INFORM YOU OF THE RESEARCH STUDY that will be conducted within Mediclinic Middle East (MCME) Emergence Centre (EC) facilities. The study is part of an educational project in fulfilment of the requirements of a PhD degree through the University of Cape Town, South Africa.

THE PURPOSE OF THIS PROJECT is to evaluate how reliable and valid the currently used triage systems are within Mediclinic's emergency centres. The study aims to standardise and validate a single locally appropriate adult and child triage system though all of Mediclinic's ECs.

THE STUDY INVOLVES several phases:

Phase 1 we will be reviewing past patient medical records.

Phase 2 of the study will require nurses to triage and complete 50 online patient scenarios based on the triage system they use within their unit.

Phase 3 will be semi-structured interviews with participants in small groups. Selected participants will also be chosen to form an advisory panel that will participate in a single focus group. At this point we will have selected and designed a single standardised triage system.

Phase 4 we will ask the nurses after attendance of a one-day training package to complete the same 50 online patient scenarios as in phase 2 based on the standardised triage system.

Phase 5 of the study will require implementing and testing the standardised triage system in the emergency centres of Mediclinic in conjunction with the current systems.

WHO HAS REVIEWED AND AUTHORISED THE STUDY? This study has been authorised by the chief clinical officer of Mediclinic Middle East and is funded by the principal researcher. The principal researcher or any of his associates do not receive any remuneration for this study. This study has further also been approved by the Doctoral Degrees Board and Human Research and Ethics Committee (Ref: 744/2014) of the University of Cape Town, South Africa; contact Tel: (+27) 21 406 6338, Email: shuretta.thomas@uct.ac.za.

HOW WILL THE STUDY AFFECT YOU? This study will benefit all MCME EC staff that is affected by the triaging system. We request that all staff give their support either directly or indirectly. Some nursing and managerial staff will be approached in good faith to participate in the study.

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project or have any questions or concerns you may speak to the principal researcher Mr Enrico Dippenaar. You may contact him at Mediclinic Atlantis, Dubai, UAE (+971 56 606 7507).

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Appendix C: participant information sheet

PARTICIPANT INFORMATION SHEET

Standardisation, validation and implementation of a triage system in a private hospital group in the United Arab Emirates

(Principal Researcher: Enrico Dippenaar, Study Number: EM2014/11, HREC Ref: 744/2014)

WE WOULD LIKE TO INVITE YOU TO PARTICIPATE in a research study that will be investigating the standardisation, validation and implementation of a triage system in a private hospital group in the United Arab Emirates. We would like you to participate as an employee of Mediclinic Middle East working in the emergency setting. Before you decide we would like you to understand why the research is being done and what it would involve for you. **One of our team will go through the information sheet with you and answer any questions you have**. We'd suggest this should take about 15 to 20 minutes. The study is part of an educational project in fulfilment of the requirements of a PhD degree through the University of Cape Town, South Africa.

THE PURPOSE OF THIS PROJECT is to evaluate how reliable and valid the currently used triage systems are within Mediclinic's emergency centres. The study aims to standardise and validate a single locally appropriate adult and child triage system though all of Mediclinic's emergency centres.

DO I HAVE TO TAKE PART? It is up to you to decide to join the study. Permission was given from the chief medical officer of Mediclinic for you to partake in this study. If you agree to take part, we will then ask you to sign a consent form. You are free to withdraw at any time, without giving a reason. Withdrawal from the study will not affect your current or future employment (Mediclinic Middle East).

THE STUDY INVOLVES several phases, in **Phase 1** we will be reviewing past patient medical records and do not require your participation. **Phase 2** of the study will require you to triage and complete 50 online patient scenarios based on the triage system you use within your unit. In **Phase 3** you will be interviewed in a small group with other participants. Selected participants will also be chosen to form an advisory panel that will participate in a single focus group. At this point we will have selected and designed a single standardised triage system, and in **Phase 4** we will ask you to complete the same 50 online patient scenarios as in phase 2 using this new standardised triage system. A one-day training package will be provided for you to become familiarised with the standardised triage system. During the last phase of the study, **Phase 5** we will be implementing the standardised triage system in the emergency centres of Mediclinic. You will be required to complete an extra triage form (standardised triage system) with the regular forms completed during your unit's triage.

EXPENSES AND PAYMENT: You will not be paid to participate in this study. The study will be conducted during your working hours and time will be allocated for you to participate.

RISKS INVOLVED IN PARTICIPATION: There are no anticipated risks to you associated with this study.

BENEFITS INVOLVED IN PARTICIPANTION: You will not receive any direct personal benefit from participation. Your involvement will have an influence in the improvement and functioning of your emergency centre and likely the quality of care provided to patients. This may indirectly benefit and simplify you're working condition and assist you in performing your daily duties.

WHAT IF THERE IS A PROBLEM? If you have any questions, concerns or complaints about this research study, its procedures, risks and benefits, you should contact the principal researcher. You may contact him anytime during or after the study has been conducted.

WHAT WILL HAPPEN IF I WANT TO WITHDRAW FROM THE STUDY? If at any time you wish to withdraw from the study, you may contact the principal researcher to convey your withdrawal. You may withdraw at any time without giving a reason. There will be no prejudice or effect on your current or future employment. All documentation that can be identified to you prior to your withdrawal will be destroyed accordingly.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL? Yes. Names on any data sheets, both electronic and hard copy will be removed once analysis starts. All data and back-ups thereof will be kept in password protected folders within Mediclinic servers from where it will be analysed. Raw data will not be transferred outside the UAE for either analysis or storage. Processed data may be transferred to associate researchers in South Africa.

WHAT WILL HAPPEN TO THE RESULTS OF THE STUDY? The findings will be published as part of a PhD thesis thought the University of Cape Town, South Africa. A report will also be drafted and submitted to Mediclinic's senior managerial board. For your convenience, a summary of the findings will be made available via Mediclinic newsletters. You will not be identifiable in any publication made.

WHO HAS REVIEWED AND AUTHORISED THE STUDY? This study has been authorised by the chief clinical officer of Mediclinic Middle East and is funded by the principal researcher. The principal researcher or any of his associates do not receive any remuneration for enrolling you into this study. This study has further also been approved by the Doctoral Degrees Board and Human Research and Ethics Committee (Ref: 744/2014) of the University of Cape Town, South Africa; contact Tel: (+27) 21 406 6338, Email: shuretta.thomas@uct.ac.za.

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project, need advice as to whether to participate, have any questions or concerns you may speak to the principal researcher Mr Enrico Dippenaar. You may contact him at Mediclinic Atlantis, Dubai, UAE (+971 56 606 7507).

Appendix D: informed consent form

Emergency Centres: **Mediclinic Middle East**
Study number: **EM2014/011**
HREC Reference number: **744/2014**
HREC Tel: **(+27) 406 6338**
HREC Email: **shuretta.thomas@uct.ac.za**
Participant identification number for this study:

PARTICIPANT INFORMED CONSENT FORM

Standardisation, validation and implementation of a triage system in a private hospital group in the United Arab Emirates

(Principal Researcher: Enrico Dippenaar)

Please initial within the box:

1. ☐ I confirm that I have read and understand the information sheet dated day/month/year for the above study. I have had the opportunity to consider the information, ask questions and have had these answered to my satisfaction.

2. ☐ I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my employment, academic progression or legal rights being affected.

3. ☐ I understand that data collected during the study, may be looked at by individuals from regulatory authorities. I give permission for these individuals to have access to my data.

4. ☐ I agree to take part in the above study.

Name of Participant	Date	Signature
Name of Researcher	Date	Signature taking consent

When completed: 1 copy for participant and 1 copy for the researcher site file

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Appendix E: confusion matrix statistics – chapter 5

	All Emergency Centres														
	Category 1			Category 2			Category 3			Category 4			Category 5		
	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper
Sensitivity - True Positive Rate (TPR)	74,7%	71,2%	78,3%	57,1%	53,1%	61,1%	47,6%	43,6%	51,7%	42,2%	38,2%	46,2%	50,0%	46,0%	54,0%
Specificity - True Negative Rate (TNR)	92,2%	91,1%	93,2%	86,9%	85,5%	88,2%	83,1%	81,5%	84,6%	84,2%	82,8%	85,7%	96,6%	95,9%	97,3%
Fall-Out - False Positive Rate (FPR)	7,8%	6,8%	8,9%	13,1%	11,8%	14,5%	16,9%	15,4%	18,5%	15,8%	14,3%	17,2%	3,4%	2,7%	4,1%
Miss Rate - False Negative Rate (FNR)	25,3%	21,7%	28,8%	42,9%	38,9%	46,9%	52,4%	48,3%	56,4%	57,8%	53,8%	61,8%	50,0%	46,0%	54,0%
Accuracy (ACC)	88,7%	87,5%	89,8%	80,9%	79,5%	82,3%	76,0%	74,4%	77,5%	75,8%	74,3%	77,4%	87,3%	86,1%	88,5%
Prevalence	20,0%	18,6%	21,4%	20,0%	18,6%	21,4%	20,0%	18,6%	21,4%	20,0%	18,6%	21,4%	20,0%	18,6%	21,4%
Precision - Positive Predictive Value (PPV)	70,4%	66,9%	74,0%	52,1%	48,2%	55,9%	41,3%	37,6%	45,0%	40,1%	36,2%	44,0%	78,7%	74,5%	82,8%
Negative Predictive Value (NPV)	93,6%	92,6%	94,6%	89,0%	87,7%	90,3%	86,4%	85,0%	87,8%	85,4%	83,9%	86,8%	88,5%	87,3%	89,8%
False Omission Rate (FOR)	6,4%	5,4%	7,4%	11,0%	9,7%	12,3%	13,6%	12,2%	15,0%	14,6%	13,2%	16,1%	11,5%	10,2%	12,7%
False Discovery Rate (FDR)	29,6%	26,0%	33,1%	47,9%	44,1%	51,8%	58,7%	55,0%	62,4%	59,9%	56,0%	63,8%	21,3%	17,2%	25,5%
Positive Likelihood Ratio (LR+)	9,5	8,8	10,2	4,3	4,1	4,6	2,8	2,6	3,0	2,7	2,5	2,8	14,8	13,3	16,2
Negative Likelihood Ratio (LR-)	0,3	0,3	0,3	0,5	0,5	0,5	0,6	0,6	0,7	0,7	0,7	0,7	0,5	0,5	0,5
Diagnostic Odds Ratio (DOR)	34,8	33,6	36,0	8,8	8,5	9,1	4,5	4,3	4,6	3,9	3,8	4,0	28,5	27,5	29,5
Prevalence Weighted (LR+)	2,4	2,2	2,5	1,1	1,1	1,1	0,7	0,7	0,7	0,7	0,6	0,7	3,7	3,4	4,0
Prevalence Weighted (LR-)	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,1	0,2	0,2	0,2	0,2	0,1	0,1	0,1
Prevalence Weighted (DOR)	34,8	33,6	36,0	8,8	8,5	9,1	4,5	4,3	4,6	3,9	3,8	4,0	28,5	27,5	29,5
*Over-Triage	0,0%	0,0%	0,0%	26,1%	22,6%	29,6%	27,1%	23,5%	30,7%	47,3%	43,3%	51,3%	50,0%	46,0%	54,0%
*Under-Triage	25,3%	21,8%	28,8%	16,8%	13,8%	19,8%	25,3%	21,8%	28,8%	10,5%	8,0%	13,0%	0,0%	0,0%	0,0%
* Cohen's Kappa	0,65	0,62	0,69	0,42	0,38	0,46	0,29	0,25	0,33	0,26	0,22	0,30	0,54	0,50	0,58
*Fleiss Kappa	0,57	0,56	0,58	0,30	0,29	0,30	0,22	0,22	0,23	0,25	0,24	0,26	0,44	0,43	0,45

	Welcare hospital														
	Category 1			Category 2			Category 3			Category 4			Category 5		
	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper
Sensitivity - True Positive Rate (TPR)	71,6%	65,2%	78,0%	53,2%	46,1%	60,3%	48,4%	41,3%	55,5%	48,4%	41,3%	55,5%	55,8%	48,7%	62,9%
Specificity - True Negative Rate (TNR)	94,7%	93,1%	96,3%	88,2%	85,9%	90,5%	82,0%	79,2%	84,7%	82,6%	79,9%	85,3%	96,8%	95,6%	98,1%
Fall-Out - False Positive Rate (FPR)	5,3%	3,7%	6,9%	11,8%	9,5%	14,1%	18,0%	15,3%	20,8%	17,4%	14,7%	20,1%	3,2%	1,9%	4,4%
Miss Rate - False Negative Rate (FNR)	28,4%	22,0%	34,8%	46,8%	39,7%	53,9%	51,6%	44,5%	58,7%	51,6%	44,5%	58,7%	44,2%	37,1%	51,3%
Accuracy (ACC)	90,1%	88,2%	92,0%	81,2%	78,7%	83,6%	75,3%	72,5%	78,0%	75,8%	73,1%	78,5%	88,6%	86,6%	90,7%
Prevalence	20,0%	17,5%	22,5%	20,0%	17,5%	22,5%	20,0%	17,5%	22,5%	20,0%	17,5%	22,5%	20,0%	17,5%	22,5%
Precision - Positive Predictive Value (PPV)	77,3%	71,1%	83,5%	52,9%	45,8%	60,0%	40,2%	33,8%	46,5%	41,1%	34,6%	47,5%	81,5%	74,9%	88,2%
Negative Predictive Value (NPV)	93,0%	91,2%	94,8%	88,3%	86,0%	90,6%	86,4%	83,9%	88,9%	86,5%	84,0%	89,0%	89,8%	87,7%	91,8%
False Omission Rate (FOR)	7,0%	5,2%	8,8%	11,7%	9,4%	14,0%	13,6%	11,1%	16,1%	13,5%	11,0%	16,0%	10,2%	8,2%	12,3%
False Discovery Rate (FDR)	22,7%	16,5%	28,9%	47,1%	40,0%	54,2%	59,8%	53,5%	66,2%	58,9%	52,5%	65,4%	18,5%	11,8%	25,1%
Positive Likelihood Ratio (LR+)	13,6	11,7	15,5	4,5	3,9	5,1	2,7	2,4	3,0	2,8	2,5	3,1	17,7	14,7	20,6
Negative Likelihood Ratio (LR-)	0,3	0,3	0,3	0,5	0,5	0,6	0,6	0,6	0,7	0,6	0,6	0,7	0,5	0,4	0,5
Diagnostic Odds Ratio (DOR)	45,3	42,5	48,2	8,4	7,9	9,0	4,3	4,0	4,5	4,5	4,2	4,7	38,7	36,3	41,1
Prevalence Weighted (LR+)	3,4	3,0	3,8	1,1	1,1	1,2	0,7	0,6	0,7	0,7	0,6	0,8	4,4	3,7	5,1
Prevalence Weighted (LR-)	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,1	0,2	0,2	0,1	0,2	0,1	0,1	0,1
Prevalence Weighted (DOR)	45,3	42,5	48,2	8,4	7,9	9,0	4,3	4,0	4,5	4,5	4,2	4,7	38,70	36,27	41,13
*Over-Triage	0,0%	0,0%	0,0%	17,4%	14,3%	20,5%	19,5%	16,3%	22,7%	41,1%	37,1%	45,1%	44,2%	40,2%	48,2%
*Under-Triage	28,4%	24,8%	32,0%	29,5%	25,8%	33,2%	32,1%	28,3%	35,9%	10,5%	8,0%	13,0%	0,0%	0,0%	0,0%
* Cohen's Kappa	0,68	0,62	0,74	0,41	0,34	0,48	0,28	0,21	0,35	0,29	0,22	0,36	0,60	0,53	0,67
*Fleiss Kappa	0,60	0,58	0,62	0,31	0,29	0,33	0,22	0,20	0,24	0,29	0,27	0,31	0,57	0,55	0,59

	City hospital														
	Category 1			Category 2			Category 3			Category 4			Category 5		
	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper
Sensitivity - True Positive Rate (TPR)	70,6%	64,5%	76,8%	60,0%	53,4%	66,6%	50,0%	43,2%	56,8%	41,4%	34,8%	48,1%	53,3%	46,6%	60,1%
Specificity - True Negative Rate (TNR)	92,3%	90,5%	94,1%	86,2%	83,9%	88,5%	83,6%	81,1%	86,1%	86,0%	83,6%	88,3%	96,0%	94,6%	97,3%
Fall-Out - False Positive Rate (FPR)	7,7%	5,9%	9,5%	13,8%	11,5%	16,1%	16,4%	13,9%	18,9%	14,0%	11,7%	16,4%	4,0%	2,7%	5,4%
Miss Rate - False Negative Rate (FNR)	29,4%	23,2%	35,5%	40,0%	33,4%	46,6%	50,0%	43,2%	56,8%	58,6%	51,9%	65,2%	46,7%	39,9%	53,4%
Accuracy (ACC)	87,9%	85,9%	89,9%	81,0%	78,6%	83,3%	76,9%	74,3%	79,4%	77,0%	74,5%	79,6%	87,4%	85,4%	89,4%
Prevalence	20,1%	17,7%	22,5%	20,0%	17,6%	22,4%	20,0%	17,6%	22,4%	20,0%	17,6%	22,4%	20,0%	17,6%	22,4%
Precision - Positive Predictive Value (PPV)	69,6%	63,5%	75,8%	52,1%	45,8%	58,4%	43,2%	37,0%	49,4%	42,4%	35,7%	49,2%	76,7%	69,9%	83,6%
Negative Predictive Value (NPV)	92,6%	90,8%	94,4%	89,6%	87,5%	91,7%	87,0%	84,7%	89,3%	85,4%	83,1%	87,8%	89,2%	87,1%	91,2%
False Omission Rate (FOR)	7,4%	5,6%	9,2%	10,4%	8,3%	12,5%	13,0%	10,7%	15,3%	14,6%	12,2%	16,9%	10,8%	8,8%	12,9%
False Discovery Rate (FDR)	30,4%	24,2%	36,5%	47,9%	41,6%	54,2%	56,8%	50,6%	63,0%	57,6%	50,8%	64,3%	23,3%	16,4%	30,1%
Positive Likelihood Ratio (LR+)	9,1	8,0	10,3	4,3	3,9	4,8	3,0	2,7	3,4	2,9	2,6	3,3	13,2	11,1	15,2
Negative Likelihood Ratio (LR-)	0,3	0,3	0,4	0,5	0,4	0,5	0,6	0,6	0,6	0,7	0,7	0,7	0,5	0,5	0,5
Diagnostic Odds Ratio (DOR)	28,7	27,0	30,4	9,4	8,8	9,9	5,1	4,8	5,4	4,3	4,1	4,6	27,1	25,5	28,7
Prevalence Weighted (LR+)	2,3	2,1	2,5	1,1	1,0	1,1	0,8	0,7	0,8	0,7	0,7	0,8	3,3	2,8	3,7
Prevalence Weighted (LR-)	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,1	0,2	0,1	0,1	0,1
Prevalence Weighted (DOR)	28,7	27,0	30,4	9,4	8,8	9,9	5,1	4,8	5,4	4,3	4,1	4,6	27,1	25,5	28,7
*Over-Triage	0,0%	0,0%	0,0%	28,1%	24,5%	31,7%	28,6%	25,0%	32,2%	45,7%	41,7%	49,7%	46,7%	42,7%	50,7%
*Under-Triage	29,0%	25,3%	32,7%	11,9%	9,3%	14,5%	21,4%	18,1%	24,7%	12,9%	10,2%	15,6%	0,0%	0,0%	0,0%
* Cohen's Kappa	0,63	0,57	0,68	0,44	0,37	0,50	0,32	0,25	0,38	0,28	0,21	0,35	0,56	0,49	0,62
*Fleiss Kappa	0,55	0,53	0,57	0,38	0,36	0,40	0,28	0,26	0,30	0,26	0,24	0,28	0,46	0,44	0,48

	Al Sufouh clinic														
	Category 1			Category 2			Category 3			Category 4			Category 5		
	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper
Sensitivity - True Positive Rate (TPR)	76,0%	67,6%	84,4%	70,0%	61,0%	79,0%	48,0%	38,2%	57,8%	49,0%	39,2%	58,8%	42,0%	32,3%	51,7%
Specificity - True Negative Rate (TNR)	92,5%	89,9%	95,1%	87,8%	84,5%	91,0%	87,0%	83,7%	90,3%	81,8%	78,0%	85,5%	97,3%	95,6%	98,9%
Fall-Out - False Positive Rate (FPR)	7,5%	4,9%	10,1%	12,3%	9,0%	15,5%	13,0%	9,7%	16,3%	18,3%	14,5%	22,0%	2,8%	1,1%	4,4%
Miss Rate - False Negative Rate (FNR)	24,0%	15,6%	32,4%	30,0%	21,0%	39,0%	52,0%	42,2%	61,8%	51,0%	41,2%	60,8%	58,0%	48,3%	67,7%
Accuracy (ACC)	89,2%	86,5%	91,9%	84,2%	81,0%	87,4%	79,2%	75,6%	82,8%	75,2%	71,4%	79,0%	86,2%	83,2%	89,2%
Prevalence	20,0%	16,5%	23,5%	20,0%	16,5%	23,5%	20,0%	16,5%	23,5%	20,0%	16,5%	23,5%	20,0%	16,5%	23,5%
Precision - Positive Predictive Value (PPV)	71,7%	63,1%	80,3%	58,8%	50,0%	67,7%	48,0%	38,2%	57,8%	40,2%	31,5%	48,9%	79,2%	68,3%	90,2%
Negative Predictive Value (NPV)	93,9%	91,5%	96,3%	92,1%	89,4%	94,8%	87,0%	83,7%	90,3%	86,5%	83,1%	90,0%	87,0%	83,9%	90,1%
False Omission Rate (FOR)	6,1%	3,7%	8,5%	7,9%	5,2%	10,6%	13,0%	9,7%	16,3%	13,5%	10,0%	16,9%	13,0%	9,9%	16,1%
False Discovery Rate (FDR)	28,3%	19,7%	36,9%	41,2%	32,3%	50,0%	52,0%	42,2%	61,8%	59,8%	51,1%	68,5%	20,8%	9,8%	31,7%
Positive Likelihood Ratio (LR+)	10,1	8,3	12,0	5,7	4,8	6,6	3,7	3,1	4,3	2,7	2,3	3,1	15,3	11,3	19,2
Negative Likelihood Ratio (LR-)	0,3	0,2	0,3	0,3	0,3	0,4	0,6	0,5	0,6	0,6	0,6	0,7	0,6	0,6	0,6
Diagnostic Odds Ratio (DOR)	39,1	35,7	42,4	16,7	15,3	18,1	6,2	5,7	6,7	4,3	4,0	4,6	25,6	23,4	27,8
Prevalence Weighted (LR+)	2,5	2,2	2,9	1,4	1,3	1,6	0,9	0,9	1,0	0,7	0,6	0,8	3,8	2,9	4,7
Prevalence Weighted (LR-)	0,1	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,1	0,2	0,1	0,1	0,2
Prevalence Weighted (DOR)	39,1	35,7	42,4	16,7	15,3	18,1	6,2	5,7	6,7	4,3	4,0	4,6	25,6	23,4	27,8
*Over-Triage	0,0%	0,0%	0,0%	24,0%	20,6%	27,4%	27,0%	23,4%	30,6%	46,0%	42,0%	50,0%	58,0%	54,0%	62,0%
*Under-Triage	24,0%	20,6%	27,4%	6,0%	4,1%	7,9%	25,0%	21,5%	28,5%	5,0%	3,2%	6,8%	0,0%	0,0%	0,0%
* Cohen's Kappa	0,67	0,59	0,75	0,54	0,45	0,63	0,35	0,25	0,45	0,28	0,19	0,38	0,48	0,37	0,58
*Fleiss Kappa	0,58	0,54	0,62	0,39	0,35	0,43	0,28	0,24	0,32	0,34	0,30	0,38	0,36	0,31	0,40

	Ibn Battuta clinic														
	Category 1			Category 2			Category 3			Category 4			Category 5		
	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper
Sensitivity - True Positive Rate (TPR)	88,9%	82,4%	95,4%	44,4%	34,2%	54,7%	40,0%	29,9%	50,1%	23,3%	14,6%	32,1%	38,9%	28,8%	49,0%
Specificity - True Negative Rate (TNR)	86,1%	82,5%	89,7%	84,7%	81,0%	88,4%	79,7%	75,6%	83,9%	86,4%	82,8%	89,9%	96,9%	95,2%	98,7%
Fall-Out - False Positive Rate (FPR)	13,9%	10,3%	17,5%	15,3%	11,6%	19,0%	20,3%	16,1%	24,4%	13,6%	10,1%	17,2%	3,1%	1,3%	4,8%
Miss Rate - False Negative Rate (FNR)	11,1%	4,6%	17,6%	55,6%	45,3%	65,8%	60,0%	49,9%	70,1%	76,7%	67,9%	85,4%	61,1%	51,0%	71,2%
Accuracy (ACC)	86,7%	83,5%	89,8%	76,7%	72,8%	80,6%	71,8%	67,6%	75,9%	73,8%	69,7%	77,8%	85,3%	82,1%	88,6%
Prevalence	20,0%	16,3%	23,7%	20,0%	16,3%	23,7%	20,0%	16,3%	23,7%	20,0%	16,3%	23,7%	20,0%	16,3%	23,7%
Precision - Positive Predictive Value (PPV)	61,5%	53,2%	69,9%	42,1%	32,2%	52,0%	33,0%	24,2%	41,9%	30,0%	19,3%	40,7%	76,1%	63,8%	88,4%
Negative Predictive Value (NPV)	96,9%	95,0%	98,8%	85,9%	82,3%	89,5%	84,2%	80,3%	88,0%	81,8%	78,0%	85,7%	86,4%	83,0%	89,7%
False Omission Rate (FOR)	3,1%	1,2%	5,0%	14,1%	10,5%	17,7%	15,8%	12,0%	19,7%	18,2%	14,3%	22,0%	13,6%	10,3%	17,0%
False Discovery Rate (FDR)	38,5%	30,1%	46,8%	57,9%	48,0%	67,8%	67,0%	58,1%	75,8%	70,0%	59,3%	80,7%	23,9%	11,6%	36,2%
Positive Likelihood Ratio (LR+)	6,4	5,4	7,4	2,9	2,4	3,4	2,0	1,7	2,2	1,7	1,5	2,0	12,7	9,2	16,3
Negative Likelihood Ratio (LR-)	0,1	0,1	0,2	0,7	0,6	0,7	0,8	0,7	0,8	0,9	0,9	0,9	0,6	0,6	0,7
Diagnostic Odds Ratio (DOR)	49,6	45,1	54,1	4,4	4,1	4,8	2,6	2,4	2,8	1,9	1,8	2,1	20,2	18,4	22,0
Prevalence Weighted (LR+)	1,6	1,4	1,8	0,7	0,6	0,8	0,5	0,4	0,6	0,4	0,3	0,5	3,2	2,4	3,9
Prevalence Weighted (LR-)	0,0	0,0	0,1	0,2	0,1	0,2	0,2	0,1	0,2	0,2	0,2	0,3	0,2	0,1	0,2
Prevalence Weighted (DOR)	49,6	45,1	54,1	4,4	4,1	4,8	2,6	2,4	2,8	1,9	1,8	2,1	20,2	18,4	22,0
*Over-Triage	0,0%	0,0%	0,0%	42,2%	38,2%	46,2%	40,0%	36,0%	44,0%	65,6%	61,8%	69,4%	61,1%	57,2%	65,0%
*Under-Triage	11,1%	8,6%	13,6%	13,3%	10,6%	16,0%	20,0%	16,8%	23,2%	11,1%	8,6%	13,6%	0,0%	0,0%	0,0%
* Cohen's Kappa	0,64	0,56	0,73	0,29	0,18	0,39	0,18	0,08	0,29	0,11	0,00	0,21	0,44	0,32	0,55
*Fleiss Kappa	0,61	0,56	0,65	0,18	0,13	0,22	0,16	0,11	0,20	0,16	0,12	0,21	0,20	0,15	0,25

Appendix F: international early warning score examples

MEWS – MODIFIED EARLY WARNING SCORE – Traditional							
Parameter	**3**	**2**	**1**	**0**	**1**	**2**	**3**
AVPU			New Confusion	Alert	Voice	Pain	Unresponsive
RR		≤ 8		9 - 14	15 - 20	21 - 29	≥ 30
SpO2							
HR		≤ 40	41 - 50	51 - 100	101 - 110	111 - 129	≥ 130
SBP	≤ 70	71 - 80	81 - 100	101 - 199		≥ 200	
Temp		≤ 35	35.1 - 36	36.1 - 38	38.1 - 38.5	≥ 38.5	

MEWS – MODIFIED EARLY WARNING SCORE – NHS Foundation (2012)							
Parameter	**3**	**2**	**1**	**0**	**1**	**2**	**3**
AVPU			New Confusion	Alert	Voice	Pain	Unresponsive
RR		8 or less		9 - 16	17 - 20	21 - 29	30 or more
SpO2				94% or more	90 - 93%	85 - 89%	84% or less
HR				51 - 100	101 - 110	111 - 129	130 or more
SBP	70 or less	71 - 80	81 - 100	101 - 199		200 or more	
Temp		35 or less	35.1 - 36	36.1 - 37.5	37.6 - 38.1	38.2 or more	

TEWS – TRIAGE EARLY WARNING SCORE – South African Triage Score (2012)							
Parameter	**3**	**2**	**1**	**0**	**1**	**2**	**3**
AVPU		Confused		Alert	Voice	Pain	Unresponsive
RR		less than 9		9 - 14	15 - 20	21 - 29	more than 29
SpO2							
HR		less than 41	41 - 50	51 - 100	101 - 110	111 - 129	more than 129
SBP	less than 71	71 - 80	81 - 100	101 - 199		more than 199	
Temp		Under 35		35 - 38.4		Over 38.4	

NATIONAL EARLY WARNING SCORE – Royal College of Physicians (2012)							
Parameter	**3**	**2**	**1**	**0**	**1**	**2**	**3**
AVPU				A			V, P, or U
RR	≤ 8		9 - 11	12 - 20		21 - 24	≥ 25
SpO2	≤ 91%	92 - 93%	94 - 95%	≥ 96%			
HR	≤ 40		41 - 50	51 - 90	91 -110	111 - 130	≥ 131
SBP	≤ 90	91 - 100	101 -110	111 - 219			≥ 220
Temp	≤ 35		35.1 - 36	36.1 - 38	38.1 - 39	≥ 39.1	

Appendix G: data collection sheet – chapter 7

PATIENT REGISTRATION STICKER

TRIAGE CATEGORY	
TIME OF TRIAGE	
TIME OF PHYSICIAN CONSULT	
TIME PATIENT LEAVES EC	

AVPU				**MOBILITY**				**MEDICAL / TRAUMA**	
Alert		**To Voice**		**Walking**		**With Help**		**Medical**	
To Pain		**Unresponsive**		**Stretcher / Immobile**				**Trauma**	

Please make a tick next to a descriptor <u>if</u> it applies to the patient, more than one descriptor may be chosen.

DESCRIPTORS			
abdominal pain		joint swelling and pain	
allergic reaction - severe		light-headedness	
anxiety – severe		obstructed airway	
arrest – code/resuscitation		obvious deformity	
asthma – severe		pain unresponsive to analgesics	
burn – facial or inhalation		palpitations	
burn less than 20%		photophobia	
burn more than 20%		poisoning/overdose	
cardiac – neck, jaw or arm pain		pregnancy and trauma	
chemical exposure		pregnancy and vaginal bleeding	
chest pain		prolapsed cord	
child – looks severely unwell		psychosis - acute	
confusion – new onset		pulsatile bleeding	
constipation – severe		respiratory distress – mild	
dehydration – adult – moderate/severe		respiratory distress – moderate	
dehydration – child – moderate/severe		respiratory distress – severe	
dialysis problems		restlessness/irritability – severe	
dislocation of finger or toe		ruptured membranes	
eye injury		seizure – current	
fracture – closed		seizure – post ictal	
fracture – open		shock – moderate	
haemoptysis		shock – severe	
haemorrhage – controlled		stroke – acute	
haemorrhage – uncontrolled		sudden throat/tongue swelling	
head injury with risk features		threatened limb	
history of loss of consciousness		trauma – major/severe	
hyperglycaemia > 17mmol/l		trauma – moderate	
hypoglycaemia < 3mmol/l		uncontrollable itching	
infant < 1 year old		unresponsive	
infection – severe		vomiting fresh blood	
joint dislocation with vascular compromise		vomiting persistently	

If you feel there are <u>any</u> other descriptors you think is important for the triage of this patient.

Appendix H: 50 vignettes – chapter 8

Triage Case Category: **CATEGORY 1 - RESUSCITATION** Time to Physician: **IMMEDIATE**

CASE #	Time	Age	Gender	Chief Complaint	Signs & Symptoms	History	T/M	LOC	Mobility	RR	HR	SBP	DBP	Temp	SpO_2	Pain	HGT
										p/min	*p/min*	*mmHg*	*mmHg*	*°C*	*%*	*/10*	*mmol*
1	3:00	25	Male	Unresponsive	Pale, cold, vomit in mouth, smell of alcohol	Excessive alcohol consumption	Medical	Unresponsive	Stretcher	8	160	120	80	36	85	n/a	3,4
2	18:00	2	Female	Active Seizures	Active tonic-clonic convulsions	Fever	Medical	Unresponsive	Abnormal for age	0	180	n/a	n/a	40	70	n/a	n/a
3	16:00	47	Female	Unresponsive	Pale, drooling from mouth	Insulin dependant diabetic	Medical	Unresponsive	Stretcher	6	145	95	70	37	85	n/a	0,4
4	17:00	72	Male	Unresponsive	Unresponsive	Unknown	Medical	Unresponsive	Stretcher	0	0	n/a	n/a	n/a	n/a	n/a	n/a

Triage Case Category: **CATEGORY 2 - EMERGENT** Time to Physician: **WITHIN 15 MINUTES**

CASE #	Time	Age	Gender	Chief Complaint	Signs & Symptoms	History	T/M	LOC	Mobility	RR	HR	SBP	DBP	Temp	SpO_2	Pain	HGT
										p/min	*p/min*	*mmHg*	*mmHg*	*°C*	*%*	*/10*	*mmol*
1	8:00	65	Male	Chest pain	Pale, profuse sweating, difficulty breathing	Chest pain started 40min ago, patient suffering from angina	Medical	Reacts to pain	Stretcher	30	145	150	110	37	90	9	3,5
2	14:00	85	Female	Severe abdominal and back pain	Signs of Shock, pulsating abdominal masses	Sudden onset	Medical	Confused	Wheelchair	32	120	80	60	37	92	10	5,4
3	21:00	6	Male	Severe shortness of breath	Difficulty breathing, stridor, drooling, hoarse voice	Fever	Medical	Irritable	Wheelchair	30	130	115	75	39	85	n/a	n/a
4	19:00	35	Female	Severe shortness of breath	Hives, flushed skin, swollen face/body/extremities	Exotic seafood dinner	Medical	Reacts to pain	Stretcher	8	140	75	60	37	90	n/a	4,4
5	1:00	1	Male	Severe shortness of breath	Wheezing, pale, poor response	Previous admission for severe bronchiolitis	Medical	Reacts to pain	Abnormal for age	48	140	90	65	37	70	n/a	4,7
6	23:00	28	Female	Poor responsiveness	Pale, decreased response, gasping respirations	Known anti-depressant use	Medical	Reacts to pain	Stretcher	6	145	150	100	37	86	n/a	1,4
7	15:00	82	Female	Sudden Collapse	Left sided paralysis, slurred speech, facial droop	Hypertension, cholesterol problems, diabetic	Medical	Confused	Wheelchair	10	140	155	115	37	95	5	4,8
8	13:00	35	Male	Headache	Severe headache, tingling sensation in hands and feet, loss of memory	Fell from 2m scaffolding and hit his head about 2 hours ago	Trauma	Confused	Wheelchair	12	110	90	70	37	97	9	5,6
9	19:00	47	Female	Dizziness	Shortness of breath, pallor, light-headedness	Hypertension, depression	Medical	Confused	Wheelchair	8	30	85	60	37	90	0	4,8
10	9:00	55	Male	Palpitations	Shortness of breath, pallor, light-headedness	Tachycardia	Medical	Alert	Wheelchair	24	135	135	95	37	95	1	4,9
11	4:00	3	Male	Rashes and fever	Drooling, no wet diapers	Onset of hives a few hours ago	Medical	Reacts to voice	Abnormal for age	30	90	110	70	39	94	2	5
12	18:00	28	Male	Altered mental status	Pale, cool, sweaty	Diabetic, no food or drink taken since morning, forgot insulin	Medical	Confused	Wheelchair	10	125	120	85	37	96	0	2

13	23:00	6	Female	Difficulty breathing	Moderate stridor, hoarse voice, anxious, tripod posture	Fever the last few days	Medical	Alert	Walking	14	135	115	80	39,5	94	4	3,4
14	21:00	2	Female	Diarrhea	Severe weakness, cold, pale, bloody stool	Diarrhea started 2 days ago, no eating and drinking since then	Medical	Reacts to voice	Abnormal for Age	24	135	100	65	37	96	n/a	2,3
15	14:00	32	Female	Abdominal Cramps	Active labour, severe abdominal pain	First pregnancy, full term	Medical	Alert	Stretcher	20	135	160	110	37,5	95	10	5,8
16	6:00	68	Male	Chest pain	Central chest pain radiating to left arm and jaw	Hypertension, cholesterol problems, pain for the last 45min	Medical	Alert	Wheelchair	25	125	130	95	37	96	6	4,2
17	14:00	56	Female	Anxiety	Emotional distress, extreme anxiety, palpitations	Erratic behaviour after receiving news of death in the family	Medical	Alert	Walking	30	120	135	90	37	98	0	5,6
18	20:00	24	Male	Chest Pain	Tenderness when palpation over the right pectoral muscle	Football hit to the right chest during a training session	Trauma	Alert	Walking	14	75	120	85	37	99	2	6,2

Triage Case Category: **CATEGORY 3 - URGENT** Time to Physician: **WITHIN 30 MINUTES**

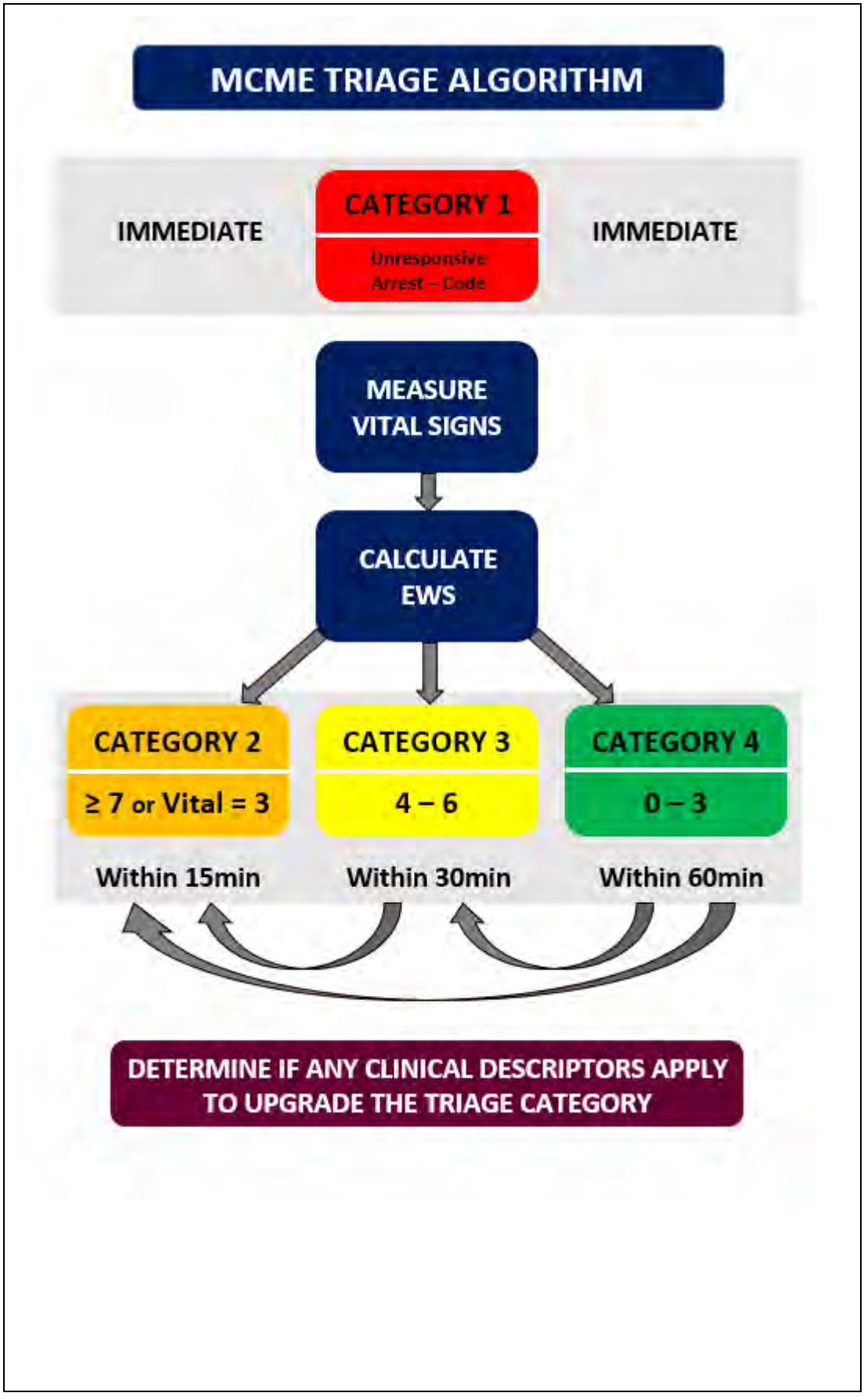
CASE #	Time	Age	Gender	Chief Complaint	Signs & Symptoms	History	T/M	LOC	Mobility	RR	HR	SBP	DBP	Temp	SpO_2	Pain	HGT
										p/min	*p/min*	*mmHg*	*mmHg*	*°C*	*%*	*/10*	*mmol*
1	12:00	37	Male	Abdominal Pain	Constipation, poor appetite, nausea	Pain has increased over the last day, no bowel movements in 24h	Medical	Alert	Walking	16	120	110	90	35,5	98	2	4,7
2	17:00	22	Male	Tiredness	Dry skin, headache, thirst	Worked construction in the sun the whole day with poor water consumption	Medical	Confused	Walking	10	110	115	90	37	99	1	4,1
3	15:00	4	Female	Asthma	Speaking in sentances, coughing, wheezing on auscultation	Known asthmatic, attack occurred during a sandstorm	Medical	Alert	Walking	30	125	110	70	37	94	0	4,7
4	10:00	85	Female	Lower back pain	Sudden onset, numbness and tingling in legs	Slipped and fell on wet floor	Trauma	Alert	Wheelchair	14	120	140	85	37	99	7	5,6
5	5:00	27	Male	Breathing difficulty	Pain increasing with movement or breathing, mild crackles, productive cough	Upper respiratory tract infection 1 week ago	Medical	Alert	Walking	25	120	120	80	38	94	3	6,1
6	2:00	1	Male	Fever	Irritable, flushed skin, loss of apatite	Symptoms began the previous day	Medical	Reacts to pain	Normal for Age	35	120	100	60	39,5	96	n/a	4,8
7	16:00	8	Female	Right arm pain	Tenderness, bruising, swelling, redness on right arm	Fell of swing at school	Trauma	Alert	Wheelchair	24	115	120	75	37	99	7	5,2
8	11:00	44	Male	Left leg pain	Headache, puss draining and red streaking away from wound	Untreated open wound injury from motorbike accident 4 days ago	Trauma	Alert	Wheelchair	16	125	140	95	37,6	99	4	5,3
9	21:00	36	Female	Seizures	Dizziness, tired feeling, abnormal behaviour	Known epileptic, seizure episode 1h ago	Medical	Confused	Wheelchair	12	110	135	80	37	98	0	4,2
10	11:00	24	Male	Burn on left forearm	Redness over left forearm 4cm wide	Accidentally stood with arm against hot pipe at work	Trauma	Alert	Walking	10	85	120	80	37	99	2	4,9
11	16:00	46	Male	Eye irritation	Small blood vessel rupture in sclera, persistent itching, redness and burning sensation	Wooden splinter was self removed about 4h ago	Trauma	Alert	Walking	12	85	130	90	37	98	3	5,6
12	7:00	38	Male	Abdominal pain	Blood in urine, nausea and vomiting	Pain started 2 days ago and is getting worse	Medical	Alert	Walking	14	90	120	85	37,5	99	5	4,7
13	17:00	40	Female	Sunburn	Feeling flushed and warm, redness over body	Sunbathing at the beach for 2 to 3h	Trauma	Alert	Walking	12	85	115	75	37	99	2	6

Triage Case Category: **CATEGORY 4 - NON-URGENT** Time to Physician: **WITHIN 60 MINUTES**

CASE #	Time	Age	Gender	Chief Complaint	Signs & Symptoms	History	T/M	LOC	Mobility	RR	HR	SBP	DBP	Temp	SpO_2	Pain	HGT
										p/min	*p/min*	*mmHg*	*mmHg*	*°C*	*%*	*/10*	*mmol*
1	14:00	10	Female	Jellyfish sting	Redness and pain over legs	Received stings whilst swimming at the beach	Trauma	Alert	Walking	20	100	120	75	37	99	2	5,6
2	19:00	3	Female	Foreign Body Ingestion	Nausea, no airway compromise	Child admits to ingesting small round toy	Trauma	Alert	Walking	20	95	105	70	37	98	3	5,4
3	13:00	54	Female	Left ear pain	Loss of hearing in left ear	Pain started 3 days ago and is getting worse	Medical	Alert	Walking	12	110	130	75	37	99	4	5,8
4	8:00	88	Female	Feeding tube problems	Feeding tube has fallen out	Accidentally pulled out feeding tube in bathroom	Medical	Alert	Wheelchair	16	95	145	95	37	97	3	3,6
5	14:00	33	Male	Nosebleed	Intermittent nosebleed	Recent nasal surgery	Medical	Alert	Walking	12	110	125	85	37	98	2	4,9
6	10:00	18	Female	Vaginal bleeding	Cramps interferes with daily activity, bleeding for more than 10 days	Regular menstrual cycle, first time this has happened	Medical	Alert	Wheelchair	16	85	110	70	37	99	4	5,7
7	5:00	29	Male	Hives	Mild swelling of extremities, diarrhea, moderate discomfort	New onset of hives after camping trip	Medical	Alert	Walking	10	75	125	85	37	99	2	4,7
8	12:00	18	Male	Abdominal Pain	Indigestion, bloating, loss of appetite	Unusually frequent bowl movements the last few days	Medical	Alert	Walking	12	80	125	85	37	99	1	4,6
9	16:00	50	Male	Back Pain	Minor discomfort to lower back	Chronic back problems	Medical	Alert	Walking	12	95	135	90	37	99	2	5,4
10	7:00	5	Female	Coughing	Productive cough	Coughing and runny nose started night before	Medical	Alert	Walking	20	85	105	70	37	99	0	5,1
11	11:00	36	Female	Diarrhea	Diarrhea and loose stools 4 times in last 24h	Consumption of spicy food the previous evening	Medical	Alert	Walking	12	95	110	85	37	99	0	4,8
12	12:00	2	Female	Scrapes and bruises	Minor scrapes and bruises over legs and hands	During playtime at school ran into the bushes and fell down	Trauma	Alert	Walking	30	120	100	65	37	99	2	4,5

13	8:00	34	Male	Sore Throat	Dry cough and scratchy throat	Up late at a concert the night before	Medical	Alert	Walking	10	90	130	90	37	99	2	5,2
14	15:00	62	Male	Nasal Congestion	Sneezing and mild cough, sore throat, nasal discharge	Grandchild has been ill the last few days as well	Medical	Alert	Walking	12	95	140	95	37	99	0	5,1
15	13:00	70	Female	Tongue problems	Sore spots and discoloration of tongue	Heavy smoker	Medical	Alert	Walking	12	85	135	100	37	99	0	5,6

Appendix I: novel triage system



MCME TRIAGE STEPS

STEP 1: Recognise

- Immediately Life-Threatening Conditions (Unresponsive, Arrest – Code)

CATEGORY 1

STEP 2: Evaluate

- Early Warning Scores & Clinical Descriptors

STEP 3: Allocate

- Any single Vital Sign that receives a score of **"3"** in the EWS will be **Category 2**
- The Highest Category selection between EWS and Clinical Descriptors shall apply

CATEGORY 2 **CATEGORY 3** **CATEGORY 4**

STEP 4: Re-evaluate

- Where possible re-evaluate and update a patients Triage Category as required

CATEGORY	DESCRIPTION	TIME TO PHYSICIAN
1	Resuscitation	Immediate
2	Emergent	Within 15min
3	Urgent	Within 30min
4	Non-Urgent	Within 60min

MCME Early Warning Score – ADULT							
	3	2	1	0	1	2	3
AVPU		New Confusion		Alert	Voice	Pain	
RR	≤ 8		9 – 11	12 – 20	21 – 24	25 – 29	≥ 30
SpO_2	≤ 91%		92 – 93%	≥ 94%			
HR	≤ 40		41 – 50	51 – 100	101 – 110	111 – 129	≥ 130
SBP	≤ 70	71 – 80	81 – 100	101 – 199		≥ 200	
Temp	≤ 35		35.1 – 36	36.1 – 38	38.1 – 39	39.1 – 41.5	≥ 41.5
Pain				0 – 2	3 – 4	5 – 7	8 – 10

MCME Early Warning Score – CHILD (1 - 12 Years Old)							
	3	2	1	0	1	2	3
AVPU		New Confusion		Alert	Voice	Pain	
RR	≤ 15	16 - 20		20 – 30	31 – 40	41 – 44	≥ 45
SpO_2	≤ 91%		92 – 93%	≥ 94%			
HR	≤ 60	60 – 70		70 – 120	121 – 130	131 – 139	≥ 140
Temp	≤ 35		35.1 – 36	36.1 – 38	38.1 – 39	39.1 – 41.5	≥ 41.5
Pain				0 – 2	3 – 4	5 – 7	8 – 10

MCME CLINICAL DESCRIPTORS		
CATEGORY 1 – RED		
Unresponsive and/or Arrest – Code		
CATEGORY 2 – ORANGE		
Allergic Reaction – Severe	Chest Pain	Burn – Major, Facial or Inhalation
Ruptured Membranes	Neonate	Respiratory Distress – Severe
Prolapsed Cord	Trauma – Major	Hypoglycaemia – Symptomatic
Seizure – Active	Stroke	Joint Dislocation With Vascular Compromise
CATEGORY 3 – YELLOW		
Dizziness	Abdominal Pain	Pregnancy – Trauma or Vaginal Bleeding
Obvious Limb Deformity	Burn – Minor	Hyperglycaemia – Symptomatic
Palpitations	Seizure – Post Ictal	Respiratory Distress – Moderate
Photophobia	Eye Injury	Restlessness/Irritability – Severe
Poisoning/Overdose	Fracture – Open	Dehydration – Child – Moderate/Severe
Trauma – Moderate	Threatened Limb	History of Loss of Consciousness
CATEGORY 4 – GREEN		

Appendix J: confusion matrix statistics – chapter 8

	All Emergency Centres											
	Category 1			Category 2			Category 3			Category 4		
	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper	Value	Lower	Upper
Sensitivity - True Positive Rate (TPR)	93,1%	89,7%	96,4%	73,3%	70,5%	76,0%	60,0%	56,3%	63,6%	82,7%	80,1%	85,3%
Specificity - True Negative Rate (TNR)	97,4%	96,8%	98,0%	94,2%	93,1%	95,3%	85,4%	83,9%	87,0%	87,3%	85,8%	88,8%
Fall-Out - False Positive Rate (FPR)	2,6%	2,0%	3,2%	5,8%	4,7%	6,9%	14,6%	13,0%	16,1%	12,7%	11,2%	14,2%
Miss Rate - False Negative Rate (FNR)	6,9%	3,6%	10,3%	26,7%	24,0%	29,5%	40,0%	36,4%	43,7%	17,3%	14,7%	19,9%
Accuracy (ACC)	97,0%	96,4%	97,7%	86,7%	85,4%	87,9%	78,8%	77,3%	80,4%	85,9%	84,6%	87,2%
Prevalence	8,0%	7,0%	9,0%	36,0%	34,2%	37,8%	26,0%	24,3%	27,7%	30,0%	28,3%	31,7%
Precision - Positive Predictive Value (PPV)	75,6%	70,4%	80,7%	87,7%	85,4%	89,9%	59,1%	55,5%	62,7%	73,6%	70,8%	76,5%
Negative Predictive Value (NPV)	99,4%	99,1%	99,7%	86,2%	84,7%	87,8%	85,9%	84,3%	87,4%	92,2%	90,9%	93,4%
False Omission Rate (FOR)	0,6%	0,3%	0,9%	13,8%	12,2%	15,3%	14,1%	12,6%	15,7%	7,8%	6,6%	9,1%
False Discovery Rate (FDR)	24,4%	19,3%	29,6%	12,3%	10,1%	14,6%	40,9%	37,3%	44,5%	26,4%	23,5%	29,2%
Positive Likelihood Ratio (LR+)	35,56	31,35	39,77	12,66	11,82	13,49	4,12	3,85	4,38	6,51	6,12	6,90
Negative Likelihood Ratio (LR-)	0,07	0,06	0,08	0,28	0,26	0,30	0,47	0,45	0,49	0,20	0,18	0,22
Diagnostic Odds Ratio (DOR)	498,69	479,89	517,48	44,58	42,92	46,24	8,79	8,48	9,10	32,90	31,68	34,12
Prevalence Weighted (LR+)	3,09	2,79	3,40	7,12	6,67	7,57	1,45	1,39	1,51	2,79	2,65	2,94
Prevalence Weighted (LR-)	0,01	0,00	0,01	0,16	0,14	0,18	0,16	0,15	0,18	0,08	0,07	0,10
Prevalence Weighted (DOR)	498,69	479,89	517,48	44,58	42,92	46,24	8,79	8,48	9,10	32,90	31,68	34,12
*Over-Triage	0,0%	0,0%	0,0%	5,2%	3,4%	7,0%	11,4%	8,8%	14,0%	17,3%	14,2%	20,4%
*Under-Triage	6,9%	4,9%	8,9%	21,5%	18,2%	24,8%	28,6%	25,0%	32,2%	0,0%	0,0%	0,0%
* Cohen's Kappa	0,82	0,78	0,86	0,70	0,67	0,73	0,45	0,41	0,49	0,68	0,65	0,71
*Fleiss Kappa	0,73	0,72	0,74	0,58	0,57	0,59	0,34	0,33	0,35	0,59	0,59	0,60