AN ANALYSIS OF PATIENTS TRANSPORTED BY A PRIVATE HELICOPTER EMERGENCY SERVICE WITHIN SOUTH AFRICA

A dissertation submitted in fulfilment of the requirements for the degree of Master of Technology: Emergency Medical Care in the Faculty of Health Sciences at the Durban University of Technology

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DECLARATION OF ORIGINALITY

This is to certify that the work is entirely my own and not of any other person, unless explicitly acknowledged (including citation of published and unpublished sources). The work has not previously been submitted in any form to the Durban University of Technology or to any other institution for assessment or for any other purpose.

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ETHICAL CLEARANCE

This is to certify that the studies contained in this dissertation have the approval of the Institutional Research Ethics Committee (IREC) of the Durban University of Technology (DUT) in KwaZulu-Natal.

The allocated Ethics Clearance number is: REC 36/12

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ABSTRACT

Introduction

A Helicopter Emergency Medical Service (HEMS) is a specialist flying emergency service where on-board medical personnel have both the knowledge and equipment to perform complicated medical procedures. There is an absence of literature describing the types of patients treated and the clinical outcome of these patients flown by Helicopter Emergency Medical Services within South Africa. The paucity of literature on this topic poses a challenge for current aeromedical services as there is no baseline information on which to base flight criteria, staffing and policy documents. This has the potential to hamper the advancement of HEMS within South Africa.

Purpose of the study

The purpose of this study was to undertake a descriptive analysis of the patients flown by the Netcare 911 HEMS over a 12 month period in both Gauteng and KwaZulu-Natal and to assess the patients' outcomes. The objectives of the study were to analyse the clinical demographics of patients transported by the Netcare 911 HEMS operation, determine the time frames from dispatch of the helicopter to delivery of the patient to the receiving hospital and undertake a correlational analysis of crew qualifications, clinical procedures performed and their outcomes at 24 hours and 72 hours. A further objective was to make recommendations regarding the refinement of current aeromedical policies as well as the education and training requirements.

Methodology

The research study was conducted utilizing a retrospective quantitative, descriptive design to undertake an analysis of patients transported by a private helicopter emergency medical service within South Africa. The records of all patients transported by the Netcare 911 HEMS operations between 01 January 2011 and 31 December 2011 were included.

Results

In the 12 month study period there were a total of 547 cases. However, the final study population was made up of 537 cases as 10 cases had to be excluded due to incomplete documentation. Of the 537 cases, 82 (15.3%) were managed by the KwaZulu-Natal HEMS and 455 (84.7%) were managed by the Gauteng HEMS. Findings revealed that the majority of patients flown in both Gauteng and KwaZulu-Natal were adult males: males (n=398; 74.1%) and adults (n=437; 81.4%).

Motor vehicle accidents were the most common incident type for both operations (n=193; 36%). At the 24-hour follow up, 339 (63.1%) patients were alive and stable and at the 72-hour follow up, 404 (75.3%) were alive and stable.

Conclusion and recommendations

The findings of this study provide valuable information that may have an impact on the current staffing and authorization criteria of South African HEMS operations.

DEDICATION

This dissertation is dedicated to:

My Mom and sister, who have always supported me in my career choice and studies. Without the two of you, I would not have achieved what I have today in my profession. I am forever grateful for all your love and support.

My four-legged companions (Daisy, Holly and Daniel), who are always close by and always manage to put a smile on my face, no matter what.

My late “step” father Doran, my heart breaks when I think of all you missed with your early passing in life, but I know you would be so proud of the woman I have become.

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PRESENTATIONS RELATED TO THIS STUDY

CONFERENCE PRESENTATIONS

Muhlbauer, D. 2012. History of helicopter emergency medical services in South Africa. Paper read at the Aeromed-Africa Conference held in Cape Town from 14-16 March 2012.

Muhlbauer, D., Naidoo, R., Hardcastle, TC., Adam, JK. 2014. An analysis of patients transported by a private helicopter emergency medical service within South Africa. Paper read at the Emergency Care Society of South Africa held in Maropeng, Gauteng from 18-20 September 2014.

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ABBREVIATIONS AND GLOSSARY OF TERMS

Advanced Life Support Paramedic (ALS):

An Advanced Life Support paramedic is able to provide an advanced level of emergency care, which includes invasive procedures such as defibrillation, advanced airway management and the administration of medications. ALS paramedics are required to register with the HPCSA.

Critical Care Assistant (CCA):

A CCA is an ALS paramedic who has completed a 1,200 hour course at either a governmental or private college. This course is usually run over a period of ten months and is accredited by the HPCSA. As it is considered a short course, this course has not been assigned an NQF level.

Dispatch:

The definition of the word dispatch is to send either someone or something rapidly to a particular place for a particular purpose. In the context of this study, the term dispatch refers to the sending of the helicopter along with the aeromedical crew to a specific incident at a specific location.

Emergency Care Practitioner (ECP):

Graduates of the four year degree programme offered at Higher Education Institutes register with the HPCSA as Emergency Care Practitioners. The scope of practice of these graduates is greater than ALS paramedics and includes thrombolysis and rapid sequence induction.

Emergency Care Technician (ECT):

Graduates of the two year diploma register with the HPCSA as Emergency Care Technicians and they have their own scope of practice which differs to the ALS paramedics and the ECPs.

Emergency department (ED):

An Emergency Department (ED) may also be known as an Accident & Emergency (A&E) Unit, Emergency Room (ER) or Casualty Department. An ED is a medical treatment facility which specializes in the acute care of patients who present in an emergency situation without making an appointment, either by their own means or by ambulance. The Emergency Department is usually found in a hospital.

Golden Hour:

The golden hour is the first hour after a traumatic injury. It is during this period that medical treatment is most effective in preventing irreversible damage, thus optimising chances of survival.

Ground Emergency Medical Service (GEMS):

A Ground Emergency Medical Service (GEMS) makes use of ambulances as vehicles for the transportation of sick or injured patients to medical facilities for further treatment of illness or injury. The crew on these vehicles are able to provide medical care to the patient during transfer. The transfer could be either a primary transfer or an inter-facility transfer.

Health Professions Council of South Africa (HPCSA):

The Health Professions Council of South Africa is a statutory regulated body established in terms of the Health Professions Act 1976 (Act No. 56 of 1974) which is mandated to provide guidance to registered healthcare practitioners through aspects of education, professional conduct, ethical behaviour and registration.

Helicopter Emergency Medical Service (HEMS):

A Helicopter Emergency Medical Service (HEMS) or air ambulance may be defined as a helicopter utilized for emergency medical assistance. A Helicopter Emergency Medical Service (HEMS) or air ambulance is essentially a flying emergency department where on-board medical personnel have both the knowledge and equipment to perform complicated medical procedures. The service may be utilized to move patients to and from healthcare facilities to improve their level of care or from the primary incident scene.

Higher Education Qualification Sub-Framework (HEQSF):

The revised HEQSF provides the basis for integrating all higher education qualifications into the National Qualifications Framework (NQF). It also provides a basis for standards development and quality assurance.

Injury Severity Score (ISS):

The ISS is an established medical score utilized to assess trauma severity. It can be used to predict mortality, morbidity and hospitalization time after trauma. Major trauma (polytrauma) is defined as an ISS greater than 15.

Inter-facility transfer:

An inter-facility transfer is the transfer of a patient between two medical facilities via either a GEMS or HEMS operation.

National Diploma Emergency Medical Care (NDip):

A National Diploma: Emergency Medical Care graduate is an ALS paramedic who has completed a three year higher education qualification which is aligned to the NQF.

National Qualifications Framework (NQF):

The NQF consists of three components: Basic education, Further Education and Training and Higher Education. The NQF also assigns level descriptors (one to ten) to qualifications to indicate the educational level of achievement necessary to obtain each qualification.

Primary flight:

A primary flight is when a HEMS operation has been dispatched to the initial scene of the incident and the patient has not yet been attended to in a medical facility, such as a clinic or hospital. The patient may have received no treatment on arrival of the helicopter or treatment may have been initiated by the GEMS crews.

Professional Board of Emergency Care (PBEC):

The Professional Board of Emergency Care serves as a coordinating body within the HPCSA. The PBEC is the professional board for all emergency care providers who are registered with them.

Rapid sequence intubation (RSI):

Rapid sequence intubation is a medical procedure involving the administration of specific medications to facilitate intubation of the trachea in an emergency setting. The main purpose of RSI is to quickly induce unconsciousness and cause paralysis which allows for easier tracheal intubation. The RSI skill forms part of the ECP scope of practice in the pre-hospital environment.

Scope of practice:

A scope of practice defines the procedures, actions and processes that are permitted for the licensed individual by the HPCSA in conjunction with the corresponding register.

Time frame:

For the purpose of this research, the time frame refers to the time: 1) taken to arrive at the scene of the incident from time of dispatch, 2) spent on the actual incident scene, 3) time taken to fly the patient to hospital from the scene and 4) the total mission time from start to end.

Trauma Score:

The trauma score is a scoring system that is utilized to evaluate patients with a traumatic injury. Scores can range from 1 to 15, with the lower scores being associated with higher mortality rates.

CHAPTER 1: OVERVIEW OF THE STUDY

1.1 Introduction

This chapter will provide the background of the study, followed by the purpose, objectives and rationale of the study. The researcher will also explain her interest in the research topic and conclude with the assumptions and limitations of the study.

1.2 Study Background

A Helicopter Emergency Medical Service (HEMS) or air ambulance may be defined as a helicopter utilized for emergency medical assistance. A Helicopter Emergency Medical Service (HEMS) or air ambulance is essentially a flying emergency department with on-board medical personnel who have both the knowledge and equipment to perform complicated medical procedures. This type of resource may be called upon in circumstances where either a traditional ground ambulance cannot reach the incident in an appropriate response time or in cases where the patient needs to be transported over a long distance or inhospitable terrain to an appropriate facility. Air transportation has the advantages of being able to speedily deliver a highly skilled medical team to an incident as well as transport a patient to the most appropriate hospital instead of the closest hospital (Farlex 2013; Wikipedia 2013a).

However, as HEMS operations represent one of the most expensive pre-hospital treatment modalities, it is essential that the benefits are taken into consideration when determining procedures and policies for its use (Galvagno *et al.* 2012). As this is an expensive scarce resource, it is essential that a developing country such as South Africa utilizes this resource cautiously.

Helicopter Emergency Medical Services originated in military operations, where helicopters were used to rescue injured soldiers and transport them to field hospitals. Military helicopter emergency services had a significant impact as it vastly improved the survival of the injured soldiers (Floccare *et al.* 2013). As the use of dedicated helicopter emergency medical operations proved to have a positive effect on reducing mortality rates during military operations, it provoked the idea of dedicated civilian air ambulances and it was not long before these started to appear internationally (Martin 2006; Wikipedia 2013a).

The use of civilian helicopters for the transport of ill or injured patients has become an important part of modern emergency care systems (Bledsoe 2003). Currently, the United States of America has in excess of 200 operations whose services are paid for primarily by the patients and their insurance companies. Switzerland, France, Austria, Italy, Scandinavia and Germany also have very successful HEMS operations (Holleran 2003; Martin 2006; Pollak *et al.* 2011).

The history of HEMS within South Africa dates back to the 1970s. Over the years, South Africa has had a number of different HEMS operations across the country, in both the private and public sectors. Currently, the HEMS environment within South Africa is comprised of three service providers: Netcare 911, ER24 and the Red Cross Air Mercy Service. For the purpose of this study, the researcher will focus on the Netcare 911 Helicopter Emergency Medical Service

At the time of this study, the Netcare 911 helicopters were based in Midrand, Gauteng and Durban North, KwaZulu-Natal. Although the KwaZulu-Natal operation forms part of this study, it was closed in 2012 due to financial reasons as the case load was too low (Netcare 911 2013). These highly equipped air ambulances were available for immediate dispatch on request to emergency situations and were staffed with a medical doctor and an Advanced Life Support paramedic.

Medical evacuations can be broadly categorized into primary flights (removal of a patient from the initial scene of the incident) and inter-facility patient transfers. Each individual flight is authorised by a medical doctor based on predetermined flight criteria, which are in accordance with international standards (Netcare 911 2013).

1.3 Rationale of the study

At present, there is an absence of literature describing the types of patients who are treated by HEMS operations within South Africa as well as the clinical outcome of these patients. The paucity of literature on this topic poses a challenge for current aeromedical services as there is no baseline information on which to base flight criteria, staffing and policy documents. This has the potential to hamper the advancement of HEMS within South Africa.

This study aims to provide an analysis of the current situation within a private HEMS operation in South Africa. This research may have a noteworthy impact on Helicopter Emergency Medical Services in South Africa as it will provide a point of reference on the nature and type of patients treated, the clinical timeframes for treatment and transportation, the nature of the skills performed, as well as adverse events, such as the morbidity and mortality outcomes of patients managed in this particular aeromedical environment.

This detailed descriptive analysis may inform the development or refinement of current aeromedical policies not only in the private sector, but also in public health as well with regards to the staffing of the helicopters. It may also inform education and training of the skill set and skill competency in the aeromedical environment.

1.4 Problem Statement

There is a paucity of data on HEMS operations within South Africa which has resulted in limited research outputs focusing on HEMS within the local context. Research needs to be conducted in the local context to better inform the standards and guidelines of the HEMS operations within South Africa as well as to ensure consistency.

1.5 Purpose of the study

The purpose of this study was to undertake a descriptive analysis of the patients flown by the Netcare 911 Helicopter Emergency Medical Service over a 12 month period in both Gauteng and KwaZulu-Natal and to assess the outcome of these patients.

1.6 Objectives of the study

The objectives of the study were to:

- analyse the clinical demographics of patients transported by the Netcare 911 HEMS operations in Gauteng and KwaZulu-Natal;
- determine the time frames from dispatch of the helicopter to delivery of the patient at the receiving hospital;
- undertake a correlational analysis of crew qualifications, clinical procedures performed and their outcomes at 24 hours and 72 hours in respect of the cases analysed; and
- make recommendations regarding the refinement of current aeromedical policies as well as education and training requirements.

1.7 Brief methodology

The research study was conducted utilizing a retrospective quantitative, descriptive design to undertake an analysis of patients transported by a private helicopter emergency medical service within South Africa. The records of all patients transported by the Netcare 911 HEMS operations between 01 January 2011 and 31 December 2011 were included.

1.8 The researcher's interest in the study

The researcher has been involved with HEMS operations in South Africa since 2001, during which time she formed part of the medical crew for a number of the HEMS operations in South Africa. In 2011 and 2012, the researcher worked as the HEMS manager for the Netcare 911 KwaZulu-Natal (KZN) operation.

A HEMS operation is a very valuable resource to have within a region. However, it is a very costly and scarce resource so it is therefore essential that it is dispatched to the most suitable patients requiring transport. Over the years of involvement with HEMS operations in South Africa, the researcher has identified a paucity of research addressing HEMS operations in South Africa specifically. This motivated the researcher to undertake this particular study.

1.9 Dissertation structure

The structure of the remaining chapters of this dissertation is as follows:

- **Chapter 2** presents the literature review in a format which addresses the objectives of the study.
- **Chapter 3** presents a discussion of the research design and methodology of the research, which includes the study design, the population, the data collection process, reliability and validity, inclusion and exclusion criteria and the ethical considerations.
- **Chapter 4** presents the results of the research in the form of discussions on the statistical output as well as illustrations in the forms of tables, graphs and charts.
- **Chapter 5** presents a discussion of the findings of the study in line with the objectives.
- **Chapter 6** provides the conclusions and recommendations of the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The literature review will begin by providing a definition for the term "Helicopter Emergency Medical Service". The researcher will then elaborate on the history of Helicopter Emergency Medical Services as well as explain the current Helicopter Emergency Medical Services that are operating both internationally and locally. Thereafter, the review will focus specifically on the Netcare 911 Helicopter Emergency Medical Service as this is the focus area for this study. The researcher will also incorporate literature from international studies which relate to the objectives of this study.

2.2 Literature Search Strategy

The literature search was a continuous process to ensure that the researcher was constantly in touch with new developments on the research topic. A search was initially undertaken online with the Elsevier Science Direct website at **http://www.sciencedirect.com/,** which allows access to journal articles subscribed to by the Durban University of Technology. The keywords and Boolean operators ("helicopter" OR "emergency helicopter" OR "aeromedical") were utilized. No limitations were placed on the search with reference to journal types and date ranges.

Further searches were conducted on the online library facility OvidSP accessed at **http://access.ovid.com,** the Google Scholar search engine at **http://scholar.google.co.za** and the Pubmed search engine at **http://www.ncbi.nlm.nih.gov/pubmed** where articles with full text availability were accessed. The same keywords and Boolean operators were utilized as in the previous search at Science Direct.

The researcher reviewed all of the abstracts returned after the searches for relevance. If the article was found to be relevant, the researcher downloaded the article to her hard drive and printed a copy. Each article was then carefully read in its entirety to determine further relevance and significance to the research topic. If the researcher found that the article was irrelevant or of no significance, it was discarded.

Whilst reading the articles, the researcher also referred to the article's citations and reference list to ensure that other articles of relevance to the research topic were not omitted.

Further searches were conducted throughout the study as and when the need arose, making use of the Ovid SP search engine at **http://access.ovid.com**. The keywords utilised were as follows:

- ("Head injury") AND ("Rapid Sequence Intubation")
- ("Injury Severity Score") AND ("Patient Outcome")

This need arose as it became apparent during the course of the research that patients with traumatic injuries, specifically head injuries, were the most common cases transported by both of the HEMS operations.

Throughout the study, the researcher also made use of relevant articles that had been referred to her by colleagues.

2.3 What is a Helicopter Emergency Medical Service?

A rotary-wing air ambulance, routinely referred to as a Helicopter Emergency Medical Service (HEMS), may be defined as a helicopter utilized for emergency medical assistance. This type of resource may be called upon in circumstances where a traditional ground ambulance cannot reach the incident in an appropriate response time or in cases where the patient needs to be transported over a long distance or inhospitable terrain to an appropriate facility. In all of these instances, air transportation is more suitable. Air transportation has the advantage of speed. It can deliver a highly skilled medical team to an incident in the least possible time, as well as extract a patient to the most appropriate hospital for that specific patient, instead of the closest hospital (Farlex 2013; Wikipedia 2013a).

2.4 The History of Helicopter Emergency Medical Services

The first written record of the term “air ambulance” is in Jules Verne’s Robur le Conquérant (1866), which describes the rescue of shipwrecked sailors by an airship (balloon) named the Albatross. Balloons were also used during the siege of Paris in 1870 to evacuate approximately 160 soldiers from the besieged city (Holleran 2003; Martin 2006; Pollak *et al.* 2011).

Subsequent to this, early HEMS operations developed largely within the military environment (Careless 2010). The first documented medical evacuation with a helicopter occurred during World War II (Taylor *et al.* 2010). In April 1944, an American military air force aircraft with three wounded British soldiers on-board was forced down in the jungle behind Japanese enemy lines near Mawlu in Burma. A United States army Sikorsky YR-4B helicopter flown by Lieutenant Carter Harman performed four trips over a period of three days to rescue all of the crew as he was only able to carry one passenger at a time (Martin 2006).

Figure 2.1: Sikorsky YR-4B helicopter (Wikipedia 2013c)

The first helicopters dedicated to provision of medical assistance were used by American forces during the Korean War from 1950 to 1953. During this war, helicopters were utilized to extract casualties from the battlefields as well as transfer critical patients to more advanced hospital ships once initial emergency treatment in the field hospitals had been completed (Holleran 2003; Careless 2010; Wikipedia 2013a).

On the 4th August 1950, the first helicopter medical evacuation was performed with a bubble fronted Bell-47 helicopter. The injured patients were transported in a basket stretcher, also known as a litter, attached to the top of the landing gear on the outside of the small helicopter. The patients were covered with blankets in an effort to maintain body heat and prevent wound contamination. Approximately 20 000 wounded soldiers were evacuated in this manner. One of the major problems with transporting the soldiers in the external litter like this was that no medical treatment could be administered during the flight (Holleran 2003; Martin 2006).

Figure 2.2: Bell-47 helicopter (*Mercy flight western New York* 2013)

Figure 2.3: Patient being loaded into litter of a Bell-47 helicopter (*Mercy flight western New York* 2013)

Literature notes that the World War II mortality rate of 4.5 deaths per 100 casualties dropped to 2.5 per 100 casualties during the Korean War. Whilst there were some technological advances in medicine during that period, the major improvement is attributed to the use of helicopters to evacuate patients to definitive care faster (Martin 2006).

The pivotal moment for aeromedical transport occurred during the Vietnam War as it was during this time that in-flight medical treatment was first introduced (Careless 2010). In the Vietnam War, a Bell UH-1 (“Huey”) helicopter was put into operation. The “Huey” could accommodate patients inside the cabin of the aircraft where medics were able to initiate medical treatment during the flight to the field hospital. The mass deployment of these helicopters reduced the average delay from time of injury until treatment to one hour. The ability to transport patients inside the cabin of the helicopter was a key variable in the reduction in mortality and morbidity. An added factor was that the aircraft could also accommodate military medics inside the aircraft who could perform advanced medical procedures which were previously only performed by physicians. This resulted in a reduction in the mortality rate to one death per 100 casualties (Holleran 2003; Martin 2006; Pollak *et al.* 2011).

Figure 2.4: Bell UH-1 ("Huey") helicopter (*Mercy flight western New York* 2013)

The impact of military HEMS was unmistakable as the survival rate of injured soldiers who were transported by helicopters to the field hospitals during the Vietnam War was vastly improved (Careless 2010). Table 2.1 depicts the impact of HEMS on the reduction in mortality rates in military conflicts.

Table 2.1: Mortality rate in military conflicts (*Mercy flight western New York* 2013)

Military Conflict	**Time from Injury to Surgery**	**Mortality Rate**
World War I (no helicopter)	12 to 18 hours	8.8%
World War II (no helicopter	6 to 12 hours	5.8%
Korea with helicopter	2 to 4 hours	2.4%
Vietnam with helicopter	1 to 1.4 hours	1.7%

The use of military aircraft as battlefield ambulances has continued to expand and develop in a number of countries (Pollak *et al.* 2011; Wikipedia 2013a). The United States military has recently made use of the UH-60 Blackhawk helicopters in both Iraq and Afghanistan to transport soldiers and civilians from the battlefield.

The first civilian application of HEMS occurred in 1958 in Etna, California when Bill Matthews started a helicopter service to ferry patients from Dr. Granville Ashcraft, who was the town's only physician, to hospitals which could provide further medical care. The town's druggist also made use of the helicopter to deliver drugs during emergency situations (Holleran 2003; Martin 2006).

In the United States of America, two programmes were implemented to determine the impact of HEMS on mortality and morbidity in civilian areas. The first of these programmes was the Coordinated Accident Rescue Endeavour – State of Mississippi (CARE-SOM) Project, which was established in Mississippi in 1969. The project involved three helicopters which were purchased through a federal grant and were strategically placed in the northern, central and southern regions of the state. At the end of the grant, the programme was deemed a success and all three of the communities were given the opportunity to continue with the HEMS. Only one of the regions elected to continue with the HEMS operation and, in doing so, established the first civilian HEMS in the United States of America. The second programme (Military Assistance to Safety and Traffic – MAST) was established in Fort Sam Houston in San Antonio, also in 1969. This programme made use of military helicopters to augment the existing civilian emergency medical services and it was also very successful in determining the need for civilian HEMS operations (Snooks *et al.* 1996; Martin 2006; Wikipedia 2013a).

As the HEMS idea was proven and accepted, dedicated civilian air ambulances started to appear internationally (Taylor *et al.* 2010; Wikipedia 2013a). In 1969, Maryland received funding to purchase a Bell Jet Ranger helicopter and one of the first formal, civilian medical evacuation programmes was started. Four helicopters staffed by paramedics were strategically placed throughout the state to allow for rapid response to emergencies. These helicopters were also used for law enforcement and traffic control (Martin 2006; Pollak *et al.* 2011).

On 01 November 1970, a civilian HEMS (Christoph 1) commenced service at the Hospital of Harlaching in Munich, Germany. The huge success of Christoph 1 led to a rapid expansion of the concept across Germany, with Christoph 10 starting operations in 1975, Christoph 20 in 1981 and Christoph 51 in 1989 (Martin 2006; Wikipedia 2013a).

In 1977, a paramedic based HEMS operation was started in Ontario, Canada and operations began with a single-rotor-wing aircraft based at Toronto. Today, this service operates 33 helicopters stationed at 26 bases across the province, which perform both primary callouts as well as inter-facility transfers in support of their ground emergency medical services (Holleran 2003; Wikipedia 2013a).

The presence of civilian HEMS is now very common and is seen as a much needed support component for ground based emergency medical services (Wikipedia 2013a).

2.5 Modern-Day Helicopter Emergency Medical Services Worldwide

The use of civilian helicopters for the transport of ill or injured patients has become an important part of modern emergency care systems (Bledsoe 2003). Currently, the United States of America has in excess of 200 HEMS operations whose services are paid for primarily by patients and insurers utilizing the service. Switzerland, France, Austria, Italy, Scandinavia and Germany also all have very successful HEMS operations (Pollak *et al.* 2011).

Air Ambulance Victoria in Australia operates five air ambulance helicopters, which are based at Essendon, Bendigo, the Latrobe Valley and Warrnambool. Four of these helicopters are used as emergency response units to critical medical situations where they can provide an advanced level of care and rapid transport to a major hospital as well as being used in search and rescue operations, winch operations and sea rescue. The fifth helicopter in the operation is used for additional emergency work and is therefore specially equipped to retrieve patients requiring emergent transfer between rural hospitals and specialist services in Melbourne (*Air ambulance Victoria* 2013).

London’s Air Ambulance is a registered non-profit organization (NPO) that operates London’s helicopter emergency medical service. The service originated in 1987 and is based at the Royal London Hospital. It offers a unique service, operating 24 hours a day, seven days a week (24/7), with the helicopter operating during daylight hours and response cars at night. The main purpose of the helicopter is to get the specialist trauma team to the patient as quickly as possible to provide care and expertise similar to that which would be experienced in an Emergency Department. The team can be airborne within two to three minutes of receiving a call and attends to an average of seven missions every 24 hours. Once the patient has been stabilized, he/she is moved to the nearest most appropriate hospital (Snooks *et al.* 1996; *London's air ambulance* 2013).

Finland is a large country with a sparse population and difficult terrain, all of which make it difficult, or sometimes even impossible, to reach a patient with a ground vehicle. Finland currently has two full-time medical helicopters which operate out of Helsinki and Turku in the southern part of the country. In addition, there are also two multi-purpose rescue helicopters which function as both medical and rescue helicopters. The funds to operate these helicopters have been raised by local sponsoring groups (Martikainen 2000).

Spain, with a population of approximately 40 million people, has a national health service which is supported by taxes. Spain has eighteen HEMS programmes, eight of which are used exclusively for medical evacuations and the remaining programmes are also used for mountain rescue, traffic control and firefighting. Twelve of the operations only operate during daylight hours and the rest are active 24 hours a day. The various programmes are all based at different locations: 44% at airports, 33% at hospitals and the rest at specific helipads. Seventy-eight percent of the HEMS programmes are only equipped to transport one patient at a time (Burillo-Putze, Duarte and Alvarez Fernandez 2001).

Helicopter Emergency Medical Services are provided worldwide as either military or civilian services. The civilian services function differently from country to country and usually fall within one of the following operating models: a) government funded, b) traditional model, c) fee-for-service, d) community based model or e) from public donations (Wikipedia 2013a).

The following is a brief description of the various models:

- Government funded model: HEMS is provided by the government either directly or by means of a contract with a commercial service provider. The government provides operating guidelines for use of the helicopter by both hospitals and emergency medical services so as to control the operating costs (Careless 2010; Wikipedia 2013a).

- Traditional model: Hospitals contract to a third party operator to provide an aircraft and pilots, while the medical team and the management of the service are provided by the hospital. This would typically be a non-profit organisation (Careless 2010).

- Fee-for-service model: HEMS costs are considerable and many of the services charge their patients to recover costs (Wikipedia 2013a).

- Community based model: A local business or a multi-national company funds a HEMS operation as a goodwill or public relations gesture. In this type of system, the funder usually takes a hands-off approach to the daily operations. This type of model may either be a profit or non-profit organization (Careless 2010; Wikipedia 2013a).

- Public donations: The HEMS is funded by public donations (Wikipedia 2013a).

The helicopters operating within a HEMS operation are equipped to an advanced life support level and are essentially seen as flying emergency departments (Careless 2010; Wikipedia 2013a). While most of the helicopters are configured to transport one patient, there are a few that are configured to fly two (Wikipedia 2013a).

2.6 Helicopter Emergency Medical Services within South Africa

The history of HEMS within South Africa dates back to the seventies. The first service was based at the then J.G. Strydom Hospital in Johannesburg. It was run as a private venture through Lions International and its main focus was to provide an inter-facility service to cardiothoracic patients. In 1977, the then Transvaal Provincial Administration took over the management of the service and the helicopter was moved to the Johannesburg General Hospital (STAR 2006).

Medical Rescue International (MRI) commenced operations in 1978 out of the Johannesburg area. Later on, MRI added a further three helicopters to their operation, basing them in Harrismith, Durban and Cape Town. However, all four of these helicopters were taken out of service in 2000 due to financial reasons (STAR 2006).

A public-private partnership was developed in 1993 between the Transvaal Provincial Administration and Europ Assistance which resulted in the leasing of two helicopters from Court Helicopters. One of these helicopters was based at the Johannesburg General Hospital in Johannesburg and the second was based at the H.F. Verwoerd Hospital in Pretoria. In 1995, with the assistance of Clinic Holdings hospital group, the base in Johannesburg became the first fully fledged 24 hour service in South Africa responding to both primary and inter-facility transfers and this service became known as 'Flight for Life'. In 1998, the service was downgraded back to a daylight only service as the government funding had been withdrawn (STAR 2006).

In the latter portion of 1999, a new commercial operation (Star Air Ambulance Services) took over the management of the Flight for Life Service. They provided a twenty-four hour service without any government subsidy. Without government funding, the organisational and financial structures needed overhauling to ensure consistent service delivery to both paying and indigent patients. This led to the service becoming a Section 21 Non-Profit Organisation known as Specialised Trauma Air Response (STAR). STAR opened a number of bases across the country: Gauteng, Tshwane, Polokwane, KwaZulu-Natal and the Western Cape (STAR 2006).

The STAR service prided itself as being one of only eighteen services worldwide at that time to crew their helicopters with both a doctor and an Advanced Life Support (ALS) paramedic at all times. On average, STAR serviced approximately 180 calls per month across the five bases. The STAR service ceased operations in 2005 due to funding issues (STAR 2006).

In 2000, the Red Cross Air Mercy Service (RCAMS) launched their first helicopter air-ambulance in the Western Cape. The RCAMS, like STAR, is a non-profit organisation (AMS 2011). All of the RCAMS helicopters operate during daylight hours, and the two KwaZulu-Natal helicopters have recently started flying limited night operations to approved hospital night rated helipads or pre-established flight pathways. Currently, the RCAMS has bases in Oudtshoorn, Durban, Richards Bay, Cape Town and Polokwane (AMS 2011).

Netcare 911, a private ambulance service, commenced operations in 2005 following on from STAR. They initially only operated out of Johannesburg, but later also launched operations in KwaZulu-Natal and Port Elizabeth in the Eastern Cape (Netcare 911 2013). The Netcare 911 HEMS operation forms the setting for this local study.

Helivac originated in 2008 as a subscription based helicopter emergency membership with the main objective of eliminating medical insurance authorisation. The Helivac aeromedical service was launched in 2009 and was funded by monthly subscription fees. The rationale behind this model was to try and minimise helicopter activation times by eliminating the pre-authorisation process which was typically used by the more traditional funding models when authorising helicopter requests. However, Helivac aeromedical services ceased operations in 2010 due to the expenses associated with operating a dedicated helicopter and they reverted back to their original model of using service providers (Helivac 2011).

ER24 EMS (Pty) Ltd is a private, national emergency medical care service. This service currently consists of five dedicated medically equipped patient transport helicopter operations in South Africa. The first helicopter commenced operations in 2010, based at Lanseria International Airport in Johannesburg and the other helicopters are located in Bloemfontein, Nelspruit, North West and Pietermaritzburg. All of these helicopters currently only operate during daylight hours (ER24 2013).

In summary, the HEMS environment within South Africa currently consists of three service providers: the RCAMS, Netcare 911 and ER24. With the various operations delivering services in different geographical areas of the country, resource duplication is rare amongst the different providers. The extensive distance between the various operations limits the direct competition between them. The focus of this study will be on the Netcare 911 HEMS operations.

2.7 Netcare 911 Helicopter Emergency Medical Service

Netcare 911 is a pre-hospital risk management and emergency assistance subsidiary of Netcare Limited. Netcare 911 was started in 1998 and since its inception has invested extensively in human and capital resources and capabilities. Netcare 911 services include: world-class emergency medical assistance, evacuation by road or air transportation, telephonic medical advisory services and a range of other products (Netcare 911 2013).

As mentioned above, one of the key services offered by Netcare 911 is to transport patients by air. Although Netcare 911 delivers both fixed wing and rotary wing services, this study will focus on the rotary-wing component delivered by Netcare 911.

Netcare 911 rotary-wing services commenced in 2005 to continue running a 24 hour HEMS operation in the Gauteng area after the closure of STAR. The helicopter was staffed with one pilot during the day and two pilots during night operations. With regards to the medical crew, Netcare 911 endeavoured to staff the helicopter with a doctor and an Advanced Life Support (ALS) paramedic at all times, but this was not always possible in the early stages of the service and on some days the helicopter was staffed by two paramedics. Later on, both of the HEMS operations were crewed with a doctor and an ALS paramedic, both of whom were required to meet specific criteria in order to remain part of the active HEMS crew. Since the completion of this study, the staffing of the Netcare 911 HEMS operations has undergone a change. With the inclusion of Rapid Sequence Intubation (RSI) into the Emergency Care Practitioner’s (ECP) scope of practice, the Netcare 911 Gauteng HEMS is now crewed with an ECP and an ALS paramedic (NDip or CCA) as standard crew. On the odd occasion when a doctor is available, the helicopter is crewed with a doctor and either an ECP or an ALS paramedic (Netcare 911 2013).

The Gauteng operation was initially based at the then Johannesburg General Hospital (Charlotte Maxeke Johannesburg Academic Hospital) in Parktown, but during the course of 2006, the operation was moved to Grand Central Airport in Midrand. Netcare 911 initially utilised the Eurocopter EC-135 helicopter, which had been used by STAR, but later changed to a BO 105 LS twin-engine helicopter, which is still currently in use (Netcare 911 2013).

A second Netcare 911 HEMS operation was opened at Virginia Airport in KwaZulu-Natal in 2006. This service was a daylight-only service and operated with a pilot, a doctor and a paramedic. This operation made use of either an AS 350 B2 Squirrel or a BO 105 LS twin-engine helicopter. This operation was closed down in September 2012 due to financial reasons as the case load was too low (Netcare 911 2013).

In April 2008, a Netcare 911 HEMS base was opened in the Eastern Cape making use of an AS 350 B2 Squirrel helicopter. This base also only operated during daylight hours and was crewed with a pilot, a doctor and an ALS paramedic. This operation was closed in 2010 as the case numbers did not justify this costly resource (Netcare 911 2013).

The KwaZulu-Natal service was still operational at the time of the study and together with the Gauteng operation formed the focus of the study. Netcare 911 leased their aircrafts and outsourced the maintenance and flight operations components of the HEMS. The Netcare 911 helicopters were staffed by both full-time employees as well as external, part-time staff. Both operations serviced primary response cases as well as inter-facility transfers and both of the helicopters were only configured to transport one patient at a time (Netcare 911 2013).

The Netcare 911 Gauteng HEMS operation is still functional and is utilized by the Gauteng Department of Health for the transportation of critically ill indigent patients. The majority of the service delivered to the Gauteng Department of Health involves the transport of patients from the pre-hospital environment to the nearest appropriate facility. This is not an exclusive relationship as it is shared with ER24 and RCAMS. Netcare also has a variety of contracts providing HEMS to both private medical aids as well as corporate clients.

The Netcare 911 HEMS operations may only be requested by qualified medical personnel. These medical personnel may either be the GEMS medical crew that were initially dispatched to a primary incident or it may be in-hospital medical personnel arranging an inter-facility transfer. Requests are placed with the flight desk, which is the dispatch centre for the HEMS operations.

2.8 HEMS Utilisation – Demographic details and case categorisation

As previously mentioned, the literature review revealed that there are a number of HEMS operations worldwide and they all seem to operate differently with regards to the operational systems, helicopter type and crew configuration. However, it goes without saying that their primary function is for the medical transportation of a patient. It is therefore important to try and determine if there are any specific categories of patients that are flown more or less frequently than others. The following literature will examine some international studies.

In a study conducted in the United Kingdom, a retrospective review of case notes for patients flown to emergency departments by the air ambulances in Wiltshire, Berkshire and Oxfordshire were studied. This specific review only focused on patients who had sustained trauma. In total, 193 patients had been transferred by the selected air ambulances and of these, 156 were trauma patients and the remaining 37 had non-traumatic medical conditions. Of the 156 trauma cases, 45 cases were excluded as the case notes contained misinformation. The case notes of the remaining 111 trauma cases revealed that there were 73 males and 38 females with a mean age of 33 years (range 1-92 years). The most common mechanism of injury were road traffic accidents (n=59) followed by horse riding injuries (n=24).

Table 2.2 is a tabulated summary of the study data (Melton *et al.* 2007).

Table 2.2: Mechanism of Injury (Melton *et al.* 2007)

Mechanism of Injury	Number of patients
Road traffic accidents	59
Horse riding injury	24
Mechanical fall	16
Sports injury	4
Paragliding injury	2
Pedestrian injury	2
Injury building site	1
Hanging	1
Burn	1
Assaulted	1

In a separate study conducted in Norway, a helicopter service took part in a study which reviewed the outcome of patients transported by this service. A total of 370 cases were included in the review. Of the total cases reviewed, 240 (65%) were male patients and the remaining 130 (35%) were female. The median age was 46 years (range 0-86) and 36 (0-82) for men and women, respectively. Approximately 43% of the patients included in this study were diagnosed with cardiovascular disease (Hotvedt *et al.* 1996).

Another study in the United States of America which compared the outcomes of patients transported by ground emergency medical services to those transported by helicopter included a total number of 258 387 patients. Of the total number of patients included in the study, only 16% were transported by helicopter. The study found that, in general, the patients transported by helicopter were younger, more frequently male and mostly victims of motor vehicle accidents or falls when compared to those transported by ground (Brown *et al.* 2010).

The researcher was only able to identify two local studies relating to specific case categorisation and demographic details of HEMS cases within the South African context. The one study focused on patients flown by an aeromedical service in KwaZulu-Natal in 1997. In total, 398 patients were airlifted by the service during this time period. The majority of the patients were younger than 50 years in age, with the highest volume of cases falling in the 21 and 40 year age groups. There were more male (63%) patients flown by the service in this time period than female patients (33%). In the traumatic cases, cervical spine and spinal injuries were the most common causes of injury (27%) in the patients transported. In the medical pathology cases, 27% of the cases flown were neonates and 31% were patients with cardio-respiratory disease (Johnson and Dimopoulos 1998).

The other local study focused on patients transported by the South African Red Cross Air Mercy Service over a five year period (01 January 2006 to 31 December 2010) in the Richards Bay area in KwaZulu-Natal. Although a total of 1 429 flights were undertaken during the five year study period, the records for three of the flights were missing. Of these, 165 (11.6%) were primary transfers and 1 253 (88.4%) were inter-facility transfers. The majority of the patients transported were adults (n=797, 61.9%), with the remainder consisting of 278 (21.6%) neonates and 194 (15.1%) paediatrics. The main indications for the HEMS cases included: 413 (32.1%) obstetrics and gynaecology, 331 (25.7%) paediatrics and 280 (21.8%) trauma cases (D'Andrea, Van Hoving and Smith 2014).

2.9 The impact HEMS has on the "Golden Hour"

The first sixty minutes from the occurrence of an emergency is referred to as the "Golden Hour", which was first described by R Adams Cowley (Bledsoe 2003). There are three peaks in mortality following a severe life threatening incident. According to Advanced Trauma Life Support, the first peak is when death cannot be prevented and patients die immediately due to fatal injuries, the second peak relates to the patients who die within 60 minutes following trauma and the last peak relates to the patients who die from complications of their injuries. The “Golden Hour”, therefore, is relevant to the second peak in patient mortality as, according to Advanced Trauma Life Support, rapid transfer to an appropriate emergency medical care facility can be potentially lifesaving for the patients who would fall into the second peak. The speed of the helicopter maximises the portion of the “Golden Hour” that a patient will spend receiving definitive care inside a hospital environment (Melton *et al.* 2007), thus improving the patient’s chance of survival (ER24 2013).

Although the speed at which a helicopter can travel reduces travel time when compared directly to ground ambulance transportation, this is only regarded as a perceived benefit as many studies have found that patient transfer by helicopter is not always faster than that by ground ambulance. It has been revealed that many factors can delay helicopter transportation, such as mobilisation time, weather conditions, ease of access and a suitable landing zone (Melton *et al.* 2007).

However, helicopter transportation definitely has the ability to shorten the time it takes to transport critically ill or injured patients to a hospital. When compared to ground ambulances, helicopters travel at a faster speed, by more direct routes and they can avoid traffic or other obstructions which may delay transport. Helicopters also play a very valuable role in their ability to transport relatively stable patients to specialised facilities for critical interventions such as cardiac catheterization or arterial thrombolysis (Svenson, O'Connor and Lindsay 2006).

There is a perception amongst healthcare providers that HEMS crews spend too much time on scene with the patient (Van Hoving, Smith and Wallis 2008). This prolonged time at the scene defies the main advantage of HEMS, which is to limit the delay to definitive care. A retrospective observational study was conducted of all critically ill patients transported in the Western Cape between September 2005 and May 2006, which calculated the mean on-scene time in each case. Of the total of 7 924 transports that took place during this period, 7 580 (95.7%) were transported by ground ambulance and the remainder by air ambulance. On average, the air transport group spent 53.2 minutes (95% CI 51.1 to 55.4) at the scene, whilst the ground transport group spent 27.9 minutes (95% CI 27.5 to 28.4) on scene. It was therefore concluded from this study, that the on-scene time of patients utilising air transport is significantly longer than those patients utilising ground transport. Although it can be noted that there are significant differences between the two modes of transport, these were not a focus point for this study (Van Hoving, Smith and Wallis 2008).

Another retrospective study was conducted which assessed the time it took emergency transport to deliver patients to the receiving hospitals. The study included 7 854 ground ambulance and 1 075 helicopter transports and three transport methods were compared: 1) ground transport, 2) helicopter dispatched simultaneously with ground unit and 3) helicopter dispatched after the ground unit. It was noted in the findings that the simultaneously dispatched helicopter transports had significantly shorter arrival times to emergency departments at all distances greater than sixteen kilometres from the receiving hospital. Helicopters that were dispatched after the ground units were faster than the ground units in distances greater than 72 kilometres. Simultaneous helicopter dispatch was faster over nearly all of the distances when compared to those cases where the helicopter was dispatched after the ground unit. However, ground transports were significantly faster when compared to air transport at distances less than sixteen kilometres from the receiving facility (Diaz, Hendey and Bivins 2005).

A further study conducted in America compared pre-hospital on-scene times for patients managed by nurse staffed emergency vehicles with the on-scene times for patients treated by a physician staffed HEMS. The study included all trauma patients treated in a priority one emergency room in a Level one trauma centre between January 2002 and 2004. Of the 1 457 patients included in the study, 1 197 received assistance from the emergency vehicles only and the other 260 patients were attended to by HEMS. The HEMS patients had a longer mean on-scene time when compared to the other group of patients (35.4 vs. 24.6 minutes; $p < 0.001$). The reasons for the prolonged on-scene times may be due to additional procedures being performed on scene by the physician, who has a greater scope of practice than the nurses (Ringburg *et al.* 2007; Butler, Anwar and Willett 2010).

In addition to primary response cases, helicopters are frequently used to move patients between hospitals for various reasons. A study was undertaken at the Intensive Care Unit (ICU) of the University of Wisconsin (UW) which included all patients transported to the unit from an outside hospital. The aim of the study was to determine whether air transportation was faster than ground transportation. Time intervals for the study were started at the time the call was received for activation of the ground or air crew. An equal number of patients were transported by air and ground and the patients were sequentially selected. The following times were recorded: time of call, dispatch time, arrival at referring hospital, departure from referring hospital and arrival at the UW. The following time intervals were calculated: dispatch time (time of call to actual dispatch), arrival time (time from dispatch to arrival at referring hospital), ground time (time from arrival at referring hospital to time of departure), transport time (time from departure to time of arrival at UW) and total transport time (time of call to arrival at UW). A total of 145 patients were included in the study. The dispatch times for ground ambulances were shorter than for the helicopter (ground 5 ± 6 minutes vs. helicopter 17 ± 8; $p < 0.001$). Ground times at the referring facility varied, but in most instances the helicopter ground times were longer (ground 25 ± 13 minutes vs. helicopter 31 ± 11; $p = 0.008$). It was suggested that the longer ground times by the HEMS crew may be due to the procedures required for patient preparation by the physicians. Arrival times, transport times and total transport times varied according to the location of the referring facility, but it was noted that transport times from all of the referring hospitals were shorter by helicopter. On average, the total transport time was significantly shorter for helicopter transfers (helicopter 83 ± 20 minutes vs. ground 105 ± 36; $p < 0.001$). This study concluded that helicopter transportation was faster than ground transportation for all of the inter-facility transfers with an average time advantage of less than ten minutes for hospitals close to UW, but up to 45 minutes for hospitals farther away (Svenson, O'Connor and Lindsay 2006).

From the literature above, it is evident that one of the main benefits of HEMS is the perceived benefit of speed. This speed has a major role to play within the "Golden Hour" and although helicopter transport may have a longer on-scene time interval in certain instances, in general total time intervals do appear to be shorter. The longer on-scene times for HEMS transfers when compared to ground ambulances can be attributed to the high level of medical care which is brought to the patient and the level of stabilization required before flight. In one retrospective study of 1 548 primary emergency HEMS missions in Germany, the average on-scene time was recorded as 26.26 minutes when compared to 22.29 minutes for ground ambulances. The same study reflected a higher rate of orotracheal intubations for the patients managed by the HEMS crew (79.9%) versus 59.7% for patients transported by ground ambulances (Mommsen *et al.* 2012). With the confined space in the helicopter, it is essential for the HEMS crew to ensure that all possible critical incidents are managed prior to take-off, whereas with a ground ambulance, these critical incidents may be managed during the transport if and when required.

2.10 The Qualification of the HEMS Medical Crew

Medical team makeup differs depending on the country, area, service provider and type of HEMS. The medical team may consist of the following members: Emergency Medical Technician, Paramedic, Flight Nurse, Doctor or Specialist (Wikipedia 2013a). The debate continues worldwide with regards to the crew on board HEMS. It has been noted that the value of carrying a doctor as part of the medical team is that they are able to perform procedural skills similar to those performed in an emergency department and they are also able to assist with clinical judgement and decision making (Snooks *et al.* 1996). The pilots employed in HEMS need a high level of experience as the conditions to which they are exposed are far more challenging than those experienced during regular flying operations (Wikipedia 2013a).

The staffing at the London HEMS operation consists of a senior trauma doctor, two pilots and an observer, who is usually a doctor or paramedic completing their first month with London's Air Ambulance (Snooks *et al.* 1996). In Spain, the HEMS crew consists of a pilot, a physician and a registered nurse and in some instances, rescuers (Burillo-Putze, Duarte and Alvarez Fernandez 2001). The staffing of HEMS operations vary internationally as some countries crew the helicopter with a doctor and a paramedic, whilst other countries make use of a physician and a registered nurse. Table 2.3 depicts the results of a survey completed in 2000 to assess the aeromedical crew configurations for 119 HEMS operations worldwide.

Table 2.3: Aeromedical services crew configurations (Myhre 1988)

Staffing	Helicopter
1 attendant	3%
2 attendants	96%
1 supplemental staff	1%
Registered nurse / Paramedic	71%
Registered nurse / Registered nurse	8%
Registered nurse / Doctor	3%
Registered nurse / EMT	1%
Registered nurse / Other	10%
Paramedic / Paramedic	5%
Other	2%

When HEMS operations first started in South Africa, the helicopters were crewed with nursing staff from the surgical intensive care unit at the Johannesburg General Hospital. Advanced Life Support paramedics were only added to the crew in 1986. Currently, the HEMS operations in South Africa make use of different staffing models, as some crew with a medical doctor and an Advanced Life Support paramedic whilst others crew with two Advanced Life Support paramedics (AMS 2011; ER24 2013; Netcare 911 2013).

At present, there are a number of qualifications that are considered to function at an Advanced Life Support level, however, the scopes of practice for these various qualifications differ. The following four qualifications are considered to be Advanced Life Support paramedics: Critical Care Assistant (CCA), Emergency Care Technician (ECT), National Diploma in Emergency Medical Care (NDip EMC) and Emergency Care Practitioner (*Health Professions Council of South Africa* 2013) .

The CCA qualification is a nine month short course, which is not registered on the National Qualifications Framework (NQF) and the NDip EMC was a three year programme offered at Higher Education Institutes, which is no longer available. With the release of the Higher Education Qualifications Sub-Framework (HEQSF) in August 2013, the education and training of pre-hospital emergency care providers is attempting to align in a national effort to encourage lifelong learning. The ECT is a two year diploma at an NQF 6 level and the Emergency Care Practitioner (ECP) is a four year professional degree at an NQF 8 level (*Health Professions Council of South Africa* 2013).

Holders of all these different qualifications are required to register annually with the Health Professions Council of South Africa (HPCSA). The HPCSA is the regulatory body for the pre-hospital emergency care providers and as such prescribes the scope of practice for the various levels of practice. The list of capabilities for the different levels of Advanced Life Support paramedics has been included as Appendix 3. It is to be noted that the CCA and NDip EMC share the same scope of practice even though their method of training and education is of a different duration. The ECP has the most extensive scope of practice with significant interventions such as rapid sequence intubation and fibrinolysis, which were added to the ECP scope in 2009. The list of medications approved for the various levels of Advanced Life Support paramedics is attached as Appendix 4 (*Health Professions Council of South Africa* 2013). The ECP has become a vital part of the HEMS crew in South Africa and has replaced the medical doctor as part of the flight crew in certain services (Netcare 911 2013).

2.11 The Impact HEMS has on Patient Outcome

There are numerous factors that are taken into account when using a helicopter to transport patients. The benefits of air transportation are usually related to the speed of transport as well as the specialised skills of the HEMS crew (McLaughlin 2002). Other benefits of utilizing HEMS operations are that they can retrieve patients from remote locations and then transport them directly to a specialist centre (Butler, Anwar and Willett 2010). However, the helicopter is a costly resource and all of the aforementioned benefits are of little value if there is no improvement in patient outcomes as a result of utilising this service.

Literature suggests that patients with time sensitive diseases benefit the most from HEMS (Floccare *et al.* 2013). This links into the main advantage of HEMS which was discussed earlier in the literature review, which is the speed of a helicopter. Helicopters have the ability to equalize distances for patients with time-sensitive diseases by providing those who are in rural areas with remote access to definitive care an equal opportunity for optimal outcome as those who are close to definitive care. Some of the time sensitive pathologies that are discussed in various studies are: traumatic haemorrhage, ST-elevation myocardial infarction, polytrauma, traumatic brain injury, burns, stroke and paediatric emergencies (Mommsen *et al.* 2012; Floccare *et al.* 2013). One study reflected that utilizing a HEMS operation for patients other than those with time-sensitive pathologies may provide no medical benefit for the patient and that the added financial cost and risk associated with HEMS transportation must also be taken into account (Floccare *et al.* 2013).

It has been found that aeromedical helicopters have had a significant beneficial impact on mortality, specifically in trauma patients with significant injuries. However, successful outcomes in these instances are largely due to the integration of the helicopter into a well-organized pre-hospital system that feeds into identified trauma centres. Moylan (1988) argues that establishment of a HEMS operation without the relevant supporting structures would lead to disarray (Moylan 1988).

A study published in the Journal of Trauma: Injury, Infection and Critical Care specified that severely injured patients who are transported to trauma centres by helicopter are more likely to survive than patients transported by ground ambulances. This is despite the fact that patients flown by helicopter are usually more severely injured, transported from further distances and require a greater number of hospital resources. In this study conducted in America, the National Trauma Databank was utilized to identify 258 387 patients who had been flown by helicopter or removed by ground ambulance to trauma centres in 2007. Sixteen percent (16%) were transported by helicopter and 84% were transported by ground ambulance. Although nearly half of the patients transported by helicopter were admitted to an intensive care unit, the patients transported by helicopter appeared to have more positive outcomes. Although it was determined that there is a difference in patient outcome between those transported by helicopter and those transported by ground ambulance, this study failed to determine a reason for this finding. The authors of the study made an assumption that it may be due to the speed of the helicopters as well as the skill of the helicopters' medical teams in being able to perform procedures which the ground crews were not qualified to perform (Brown *et al.* 2010).

In Rotterdam, the Netherlands, a HEMS staffed with a trauma physician is utilized to provide additional therapeutic care at incidents. A study was performed to evaluate the influence the service had on the chance of survival of severely injured trauma patients. The study design involved a two year prospective observational study and 346 patients were included. Two hundred and thirty nine patients (n=239) were treated by ambulance personnel alone and 107 patients received additional treatment from the HEMS team. Patients who were treated by the HEMS crew had a lower Glasgow Coma Score (GCS) when compared to those treated by ambulance personnel (mean 8.9 versus 10.6; $P = 0.001$) and they also had a higher Injury Severity Score (ISS) (mean 30.9 versus 25.3; $P < 0.001$). The findings of this study indicated that patients treated by the HEMS team had an approximately twofold better chance of survival than those treated solely by the ground crews (Frankema *et al.* 2004).

Helicopters are also frequently used for inter-facility transfers of injured patients to a trauma centre. A study was conducted which assessed 74 779 patients who were transported either by a helicopter or ground emergency vehicle. Patients transported by helicopter made up 20% of the population and those transported by ground made up 80% of the population. The mean ISS was higher in the patients transported by helicopter (17 ± 11 vs. 12 ± 9; $p < 0.01$) as was the number of patients with an ISS > 15 (49% vs. 28%). The patients transported by helicopter had higher rates of admission to intensive care units (54% vs. 29%), shorter transport times (61 ± 55 minutes vs. 98 ± 71 minutes; $p < 0.01$) and they had shorter overall pre-hospital times (135 minutes vs. 202; $p < 0.01$). According to the findings, however, helicopter transportation was not a predictor of overall survival in patients with an ISS ≤ 15. In patients with an ISS > 15, helicopter transportation was a positive predictor of survival (OR, 1.09; 95% CI, 1.02-1.17; $p = 0.01$). In summary, the patients who were transported by helicopter were more severely injured and they required more hospital resources than the patients who were transported by ground. The helicopter transportation also offered shorter transport times as well as shorter overall pre-hospital times for patients with an ISS > 15. Helicopter transportation for these patients was definitely an encouraging predictor of survival (Brown *et al.* 2011).

A study performed in North Carolina compared the outcome of patients transported by helicopter and those transported by ground ambulance between 1987 and 1993. A total of 1 346 patients (7.3% of the total) were transported to the trauma centre by helicopter and 17 144 were transported by ground ambulance. In the patients transported by helicopter, the mean Trauma Score was lower (12 ± 3.6) versus 14.3 ± 3.6 ($p < 0.001$) and the mean ISS was higher (17 ± 11.1) versus 10.8 ± 8.4 ($p < 0.001$). The findings of this study indicated that the outcomes were not uniformly better among patients transported by helicopter. Only small subsets of patients that are transported by helicopter seem to have a chance of improved survival based solely on their helicopter transport (Cunningham *et al.* 1997).

A study was conducted for a period of two years at a helicopter service which is based at the University Hospital of Tromsø in northern Norway. The helicopter, staffed with a pilot, a paramedic and an anaesthetist, services a rural population of approximately 80 000 people with the most distant point from the base being about 45 minutes away by air and four hours by ground ambulance. During the study period, the helicopter was requested for 464 patients and after all of the exclusion criteria of the study had been applied, 370 cases were left for inclusion. Case reports for each of the 370 cases were compiled by three consulting anaesthetists. The reports included time of each flight, symptoms, signs, diagnoses, and pre-hospital as well as in-hospital management. The researchers then came to a final conclusion on each of the case reports as to whether the patient had benefited from the helicopter evacuation or not. Results showed that in 283 of the 370 (76%) cases patients had gained no additional health benefits from the use of the helicopter as opposed to a ground ambulance. In the remaining 87 cases (24%), the anaesthetists felt that there may have been some benefit. The main reason for the "no-benefit" conclusion was that the patients received no further treatment during the flight or on arrival at the hospital over and above what they would have received by the crew manning the ground ambulance (Hotvedt *et al.* 1996).

In the United Kingdom, a retrospective study was performed on the case notes of all patients who had been transferred by helicopter to the Great Western Hospital between January 2003 and September 2004. One of the objectives of this study was to record patient outcomes, with specific reference to trauma patients. Once all of the case notes had been reviewed, 111 cases were included and the immediate and long-term outcomes were recorded. The findings revealed that a concerning number (45) of the patients transported by helicopter had been immediately discharged without any admission to the hospital.

Table 2.4 summarises the immediate outcome of the trauma patients transported by the HEMS operation, while Table 2.5 summarises the long term outcome (Melton *et al.* 2007).

Table 2.4: Immediate outcome of trauma patients transported by a HEMS operation in the United Kingdom (Melton *et al.* 2007)

Immediate Outcome	Number of patients
Discharge	45
Intensive Care Unit	5
Ward	37
Theatre to ward	14
Theatre to ICU	2
Ward to theatre	4
Transfer to tertiary referral hospital	2
Death	2

Table 2.5: Long-term outcome of trauma patients transported by a HEMS operation in the United Kingdom (Melton *et al.* 2007)

Long-term Outcome	Number of patients
No follow up at Great Western Hospital	58
Follow up at other hospital	8
Complete recovery	37
Finger stiffness	1
Painful hip	2
Mal-union humerus	1
AVN talus	1
Delayed union humerus	1
C6 radiculopathy	1
Infected metalwork in humeral nail	1

There are conflicting reports in current literature on whether HEMS transport has an effect on post-trauma mortality, with some studies finding no significant benefit and others showing a mortality benefit. It is important to note, however, that some of the earliest studies into patient outcome date back to the 1980s and therefore findings from these studies should be interpreted with caution as HEMS operations have changed quite significantly since then.

There are a multitude of factors which all have a role to play in patient outcome and all of these factors vary between services and different countries (Butler, Anwar and Willett 2010). An interesting finding by Chappel et al., (2002) is that the termination of a hospital-based air ambulance service had no measurable negative impact on trauma patient outcomes (Chappel *et al.* 2002).

2.12 Conclusion

The literature review has highlighted a number of international studies relating to HEMS. However, the researcher was only able to find a few studies which related specifically to the South African environment. The purpose of this research project was to retrospectively analyse data from a HEMS operation within South Africa, focusing on patient demographics, time intervals and patient outcomes.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter will discuss the research design and methodology of the study focusing on the setting, population, data collection procedure, data analysis and ethical considerations.

3.2 Study Design

This research study was conducted utilizing a retrospective quantitative, descriptive design to undertake an analysis of patients transported by a private helicopter emergency medical service within South Africa.

A retrospective study is a study that takes a look back at events that have already taken place and involves the researcher collecting data from past records (Creswell *et al.* 2007). The purpose of quantitative research is to describe events by collecting numerical data which is then analysed utilizing statistics (Cohen, Manion and Morison 2000). The quantitative, descriptive design was selected as it establishes associations between variables (Babbie 2010). Descriptive research involves the identification of characteristics of a particular occurrence based on an observational basis and it may also include a correlational analysis between two or more variables (Williams 2007). The retrospective quantitative, descriptive design was ideally suited for this study.

3.3 Study Setting

The study was set in South Africa and focused on patients transported by a private HEMS operation within South Africa, Netcare 911. The purpose of the study was to undertake a descriptive analysis of the patients flown by the Netcare 911 Helicopter Emergency Medical Service over a 12 month period in both Gauteng and KwaZulu-Natal and to assess the outcome of these patients. At the time of the study, the Netcare 911 helicopters were based in

Midrand, Gauteng and Durban North, KwaZulu-Natal. However, the KwaZulu-Natal operation was subsequently closed down in September 2012 due to financial reasons as the case load was too low (Netcare 911 2013).

While Netcare 911 delivers both a fixed wing and rotary-wing service, this study focused on the rotary-wing service. The fixed wing operation was excluded as it was beyond the scope of this study as the operating procedures are very different to that of a HEMS operation.

Netcare 911 rotary-wing services commenced in 2005 to continue running a 24 hour HEMS operation in the Gauteng area after the closure of STAR. The Gauteng operation was initially based at the then Johannesburg General Hospital (Charlotte Maxeke Johannesburg Academic Hospital) in Parktown, but during the course of 2006, the base was moved to Grand Central Airport in Midrand. A second Netcare 911 HEMS operation was opened at Virginia Airport in KwaZulu-Natal in 2006, operating as a daylight-only service. While it has since closed down, it was operating at the time of the study and forms part of the study. In April 2008, another Netcare 911 HEMS base was opened in the Eastern Cape, but this operation was closed in 2010 as the case numbers did not justify this costly resource.

At the time of the study, the Gauteng and KwaZulu-Natal HEMS operations serviced primary call outs as well as inter-facility transfers and both of the helicopters were only configured to transport one patient at a time.

Figure 3.1 is a map of South Africa reflecting its 52 districts. The patients that were transported by both the Gauteng and KwaZulu-Natal Netcare 911 HEMS operations were removed from 27 of these districts.

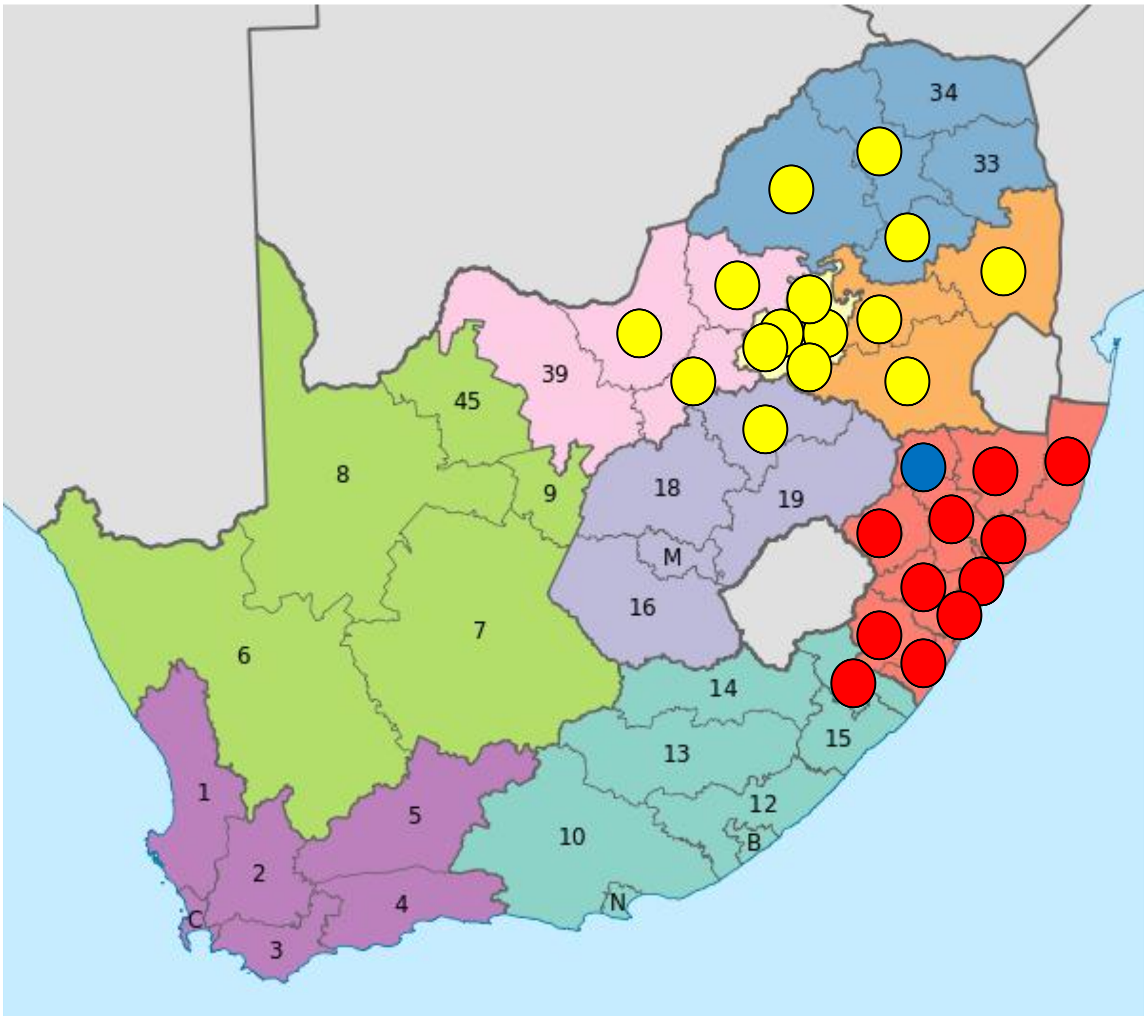


Figure 3.1: Map of South Africa depicting the 52 districts (Wikipedia 2013b)

Districts utilized by the Netcare 911 Gauteng HEMS operation

Districts utilized by the Netcare 911 KwaZulu-Natal HEMS operation

Districts utilized by the Netcare 911 Gauteng and KwaZulu-Natal HEMS operations

With regards to the medical crew, Netcare 911 endeavoured to staff the helicopters at all times with a doctor and an Advanced Life Support paramedic, but this was not always achieved in the early stages of the service, and on some days the helicopter was staffed by two Advanced Life Support (ALS) paramedics. Later on, both of the HEMS operations were crewed with a doctor and an ALS paramedic who needed to meet specific criteria in order to remain part of the active HEMS crew. These requirements are documented in a standard operating procedure (NTC911 – HEMS – 007 – Active HEMS flight crew requirements) and include a Class II flight medical certificate, CAT-138 course and current American Heart Association certification in Advanced Cardiovascular Life Support (ACLS) and Paediatric Advanced Life Support (PALS). Since the completion of this study, the staffing of the Netcare 911 Gauteng HEMS operation has undergone a change. With the addition of Rapid Sequence Intubation (RSI) to the Emergency Care Practitioner (ECP) scope of practice, the Netcare 911 Gauteng HEMS is now crewed with an ECP and an ALS paramedic (NDip or CCA) as standard crew. On the odd occasion, when a doctor is available, the helicopter is crewed with a doctor and then either an ECP or ALS paramedic (NDip or CCA) to make up the second medical crew.

Netcare 911 has a structured clinical governance system in place and all of the information relating to the cases flown by the helicopters can be accessed via the Clinical Audit and Reporting System (CARS), which is an electronic database. All cases flown by the Netcare 911 HEMS operations are reviewed by an expert panel of external clinical consultants and the cases are also discussed at regional monthly morbidity and mortality meetings. The data which was accessed for the purpose of this study was accessed on CARS.

3.4 Study target and sample population

The records of all patients who had been transported by the Netcare 911 Helicopter Emergency Medical Service between 01 January 2011 and 31 December 2011 were included. Although the electronic database has been functional for a number of years, the researcher selected this specific time period due to it being the most recent, comprehensive and complete data set. By analysing the cases flown over a 12 month cycle, a fair representation was achieved. During the 12 month period, both of the Netcare 911 HEMS operations attended to a total number of 547 cases. Of these, 460 cases were serviced by the Gauteng operation and 87 cases were serviced by the KwaZulu-Natal operation. The final study population was made up of 537 cases as ten (10) cases had to be excluded as not all of the documentation was available on CARS.

3.5 Inclusion and exclusion criteria

Inclusion Criteria:

All patients transported by the Netcare 911 Helicopter Emergency Medical Service between the 01 January 2011 and 31 December 2011 who had the following documentation available on CARS were included in the study: Electronic Patient Care Record, Flight Assessment Form, Flight Follow Up Sheet and Flight Log.

Exclusion Criteria:

Any cases in the selected time period that did not have all of the required documentation mentioned above.

3.6 Data collection procedure

Once ethical clearance to conduct the study had been received from the Durban University of Technology Institutional Research Ethics Committee Chairperson (Appendix 1), the researcher sent a letter to the Netcare 911 Research Committee requesting permission to access the CARS electronic database and permission was granted by the Chairperson (Appendix 2). A copy of the proposal was also served to the Netcare 911 Research Committee for final approval.

Once approval had been received, the relevant data was extracted from the CARS database and entered onto an electronic data collection tool (Appendix 5). The researcher sat in a secure office at the Netcare Education Faculty of Emergency and Critical Care campus in Durban North, KwaZulu-Natal. A laptop was utilized to access CARS and a password was required to access this database. The information was captured into a password protected file. Random audits of the data entries were performed by the researcher’s supervisor. The raw data was then analyzed, synthesized and interpreted to address the research aims and objectives.

3.7 Data collection source

The demographics, flight times and patient outcomes for the study were extracted off pre-existing electronic documentation utilized by Netcare 911 that had been loaded onto the electronic database known as the Clinical Audit and Reporting System (CARS). A flight assessment form (Appendix 6) is completed prior to each flight to indicate the authorisation criteria that were met to approve the flight and an Electronic Patient Report Form (EPRF) is completed after each HEMS patient transport (Appendix 7). The HEMS division has a standard operating procedure for the completion of the EPRF (NTC911 – HEMS – 005 – IT and EPRF management). The EPRF is completed by the most senior medical person, most frequently the medical doctor, and cannot be finalized and closed until all information has been entered. The completed EPRF is then checked by the second medical crew member, who is the ECP or Advanced Life Support paramedic and then loaded onto CARS along with the initial flight assessment form and the patient follow up form (Appendix 8). Netcare 911 has a standard procedure with regards to the follow up of all patients transported by the HEMS operation, with all cases being followed up by one of the medical officers after a period of 24 hours and then again after a period of 72 hours. This follow up information is inserted onto the follow-up template and this document is also loaded onto CARS.

All of this documentation is submitted to a panel of external clinical consultants to undergo a process of clinical governance. In addition to this, monthly regional morbidity and mortality meetings are held for the HEMS crew to discuss the clinical cases with the input from the external clinical consultants. All feedback from the clinical consultants is also loaded onto

CARS. A flight log (Appendix 9) is also completed by the pilot and this document is utilized by the billing department as it reflects the flight times. Figure 3.2 depicts the flow of documentation for each flight before it is loaded onto CARS.

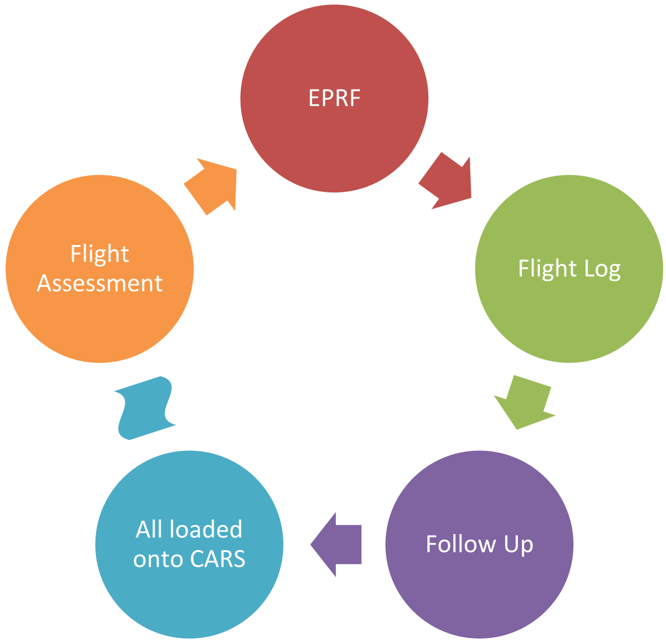


Figure 3.2: Documentation workflow process

3.8 Reliability and validity of data source

As previously mentioned, CARS is an electronic database and the Netcare 911 Information Technology (IT) department is responsible for the setup and maintenance of this database. The database uses an ASP.Net platform as well as .Net WCF web service to direct the data to the server. The server uses Microsoft Windows Server 2003/2008. Security is provided on all of the systems as all applications have a login and password which are required with different levels of security, depending on the need. All data, whether it is an original submission or a change, can be traced to a specific time and person. Netcare 911 has a backup server so that in the event of the first server crashing, the backup server can be utilised while corrective action is taken on the first. Backups are done daily on all servers by a fastback server and all backups are stored off site.

The actual clinical information loaded onto CARS relating to patient transfers is reviewed by the panel of external clinical consultants, the staff within the medical division at Netcare 911 and at the monthly morbidity and mortality meeting. As this was an existing database that had been functional for a number of years, there was no need to pilot this data source. All of the information entered into the data collection template was randomly verified and checked for accuracy by the researcher’s supervisor, co-supervisors and statistician.

3.9 Reliability and validity of the data collection tool

Reliability in research is defined as the degree to which the selected data collection tool produces stable as well as consistent results. High reliability is achieved when the data collection tool produces the same results if the research were to be repeated on the same sample. Validity refers to how well the data collection tool measures what it was intended to measure (Phelan and Wren 2005; Creswell *et al.* 2007). The data collection tool (Appendix 5) was designed with specific criteria in mind to address the aims and objectives of this research topic. All of the information required to complete the template was extracted directly from the CARS database.

The data collection tool was authenticated by the researcher’s supervisor and co-supervisors. With reference to the reliability of the data entered into the data collection tool, I was the only individual to input data into the data collection template. The data was then verified and appraised by my supervisor and co-supervisors. The data collection tool was also reviewed by an expert panel in the field of emergency medical care during the presentation of my research proposal to the academic staff at the Durban University of Technology Department of Emergency Medical Care and Rescue.

3.10 Data analysis

The service of a professional statistician was used to analyse the raw data. The computer programme utilized by the statistician was SPSS Statistics Version 21.0. The statistical aspect of the research was comprised of descriptive statistics as well as inferential statistics.

Descriptive statistics make use of frequency and cross tabulation tables and various types of graphs which may include pie charts and bar graphs. Descriptive statistics is the process of quantitatively explaining the core features of a collection of data. The aim of descriptive statistics is to provide summaries about the sample and observations that may have been made (Creswell 2009). Cross tabulation shows the joint distribution of two or more variables. The variables are most commonly presented as a contingency table in a matrix format as this allows for the distribution of two or more variables simultaneously (Creswell 2009).

Inferential statistics relate to the testing of hypotheses. The independent t-test is the most frequently utilised test to test for a significant difference between two variables. A significant test result is reflected when the "p value = < 0.05". Inferential statistics allows the researcher to draw conclusions from data about the populations (Creswell 2009). The chi-square and Fisher's exact test were utilized to test for statistical significance in a data set. The chi-square test was utilized to assess the relationship or association between two nominal variables and the Fisher's exact test was utilized to assess the significance of the association between two nominal variables when both of the variables only have two categories and the sample size is small (Creswell *et al.* 2007; McDonald 2014). The Fisher's exact test is a more accurate test when compared to the chi-square test especially when the expected numbers are small.

3.11 Ethical considerations

The study was conducted following the guidelines of the policy document outlining Durban University of Technology's ethical considerations for the conduct of research in the Faculty of Health Sciences. The four principles guiding ethics in research are beneficence, non-maleficence, respect for human dignity and justice (Callahan and Hobbs 1998; *Ethics at a glance* 2013).

- The principle of beneficence refers to the obligation on the part of the researcher to maximise the benefits and minimize the risk of harm to any persons or organizations partaking in the study. The researcher ensured that all raw data was managed with the strictest confidence and that all personal information obtained during the data collection process could only be accessed by the researcher and supervisors (Gillon 1994).

- The principle of non-maleficence requires that one does no harm to others, with particular reference to intentional or avoidable harm. The data collected for this study was retrospective in nature; therefore, no patients were harmed during the study (Gillon 1994).

- Respect for human dignity is essential in the conduct of research. The researcher ensured that no identifying data with reference to patients, supervising practitioners and hospitals were recorded at any stage during the data collection process. All of the raw data that was collected will remain confidential and will be stored in a password protected file at all times. Only the researcher has access to this file (Ashcroft *et al.* 2007).

- The principle of justice refers to the equitable selection of participants. As the sample population for this study consisted of all of the cases attended to by both of the Netcare 911 HEMS operations, there can be no prejudice in the selection of participants (*Ethics at a glance* 2013).

Consent to conduct the study was obtained from the Durban University of Technology Institutional Research Ethics Committee Chairperson as well as the Netcare 911 Research Committee. No information can be traced back to individual patients. Although the clinical records on the electronic database, CARS, contained patient information, each clinical record was assigned a number and no patient identifying data, such as names and addresses were recorded at any stage. All data was collected and entered into an electronic spread sheet; Microsoft Office Excel © 2007, with password protection. The data will be stored in a password protected file for a period of fifteen years and thereafter the file will be destroyed. All hard copies will be shredded and the electronic files will be deleted. The researcher also volunteered to sign a confidentiality agreement with Netcare 911 (Appendix 10).

The researcher is employed by Netcare Education as the Campus Manager for the Faculty of Emergency and Critical Care in KwaZulu-Natal. This did not create a bias as the data being assessed was retrospective in nature.

3.12 Conclusion

This chapter dealt with the research design and methodology of the study and although some difficulties were experienced with the actual data collection procedure, valuable information was still obtained in order to address the research aims and objectives. The following chapter will present a comprehensive analysis of the results descriptively with the assistance of tables and graphs when needed.

CHAPTER 4: RESULTS

4.1 Introduction

This chapter presents detailed results from the data analysis in relation to the aim and objectives of the study. The results will be presented in a manner that addresses the objectives of the study which will include the HEMS base activity, patient demographics, dispatch information, time frames, clinical procedures and patient outcome. The results will be presented in the form of pie charts, graphs and tables together with a brief descriptive analysis.

4.2 HEMS Base Activity

The following section will address the activity at the two HEMS operations.

4.2.1 Call volume per HEMS operation

During the 12 month study period, a total of 537 cases were serviced by the Netcare 911 HEMS operation. The proportion of cases dealt with by the Gauteng operation as compared to the KwaZulu-Natal operation is depicted in Figure 4.1.

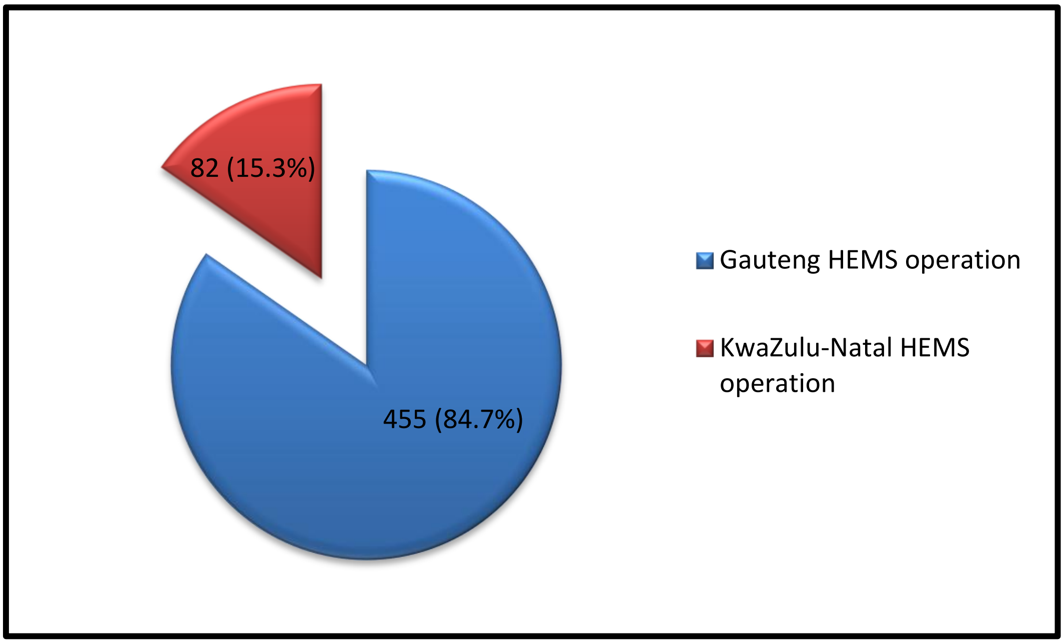


Figure 4.1: Call Volume per HEMS operation

All 537 cases were included in the study. Of the 537 cases, 455 (84.7%) were managed by the Netcare 911 Gauteng HEMS operation and the remaining 82 (15.3%) were managed by the HEMS in KwaZulu-Natal. It should be noted, however, that the KwaZulu-Natal HEMS operation operated one helicopter during daylight hours only and the Gauteng HEMS operation operated one helicopter over a 24-hour period (day and night). Chi-square tests showed a statistical significance in the call volume split between the two HEMS operations ($p = < 0.05$: CI 99%).

4.2.2 Call volume per South African district

South Africa is divided into nine provinces and these provinces are further divided into 52 districts. At the time of the study, the two Netcare 911 HEMS operations were situated in the two provinces of Gauteng and Kwa-Zulu Natal and analysis of the records showed that the two Netcare 911 HEMS operations generally retrieved patients from within their own provinces. However, in certain instances, both of the helicopters retrieved patients from outside of their respective provinces.

Table 4.1 shows a breakdown of the districts within South Africa from which the 537 cases were transported by both of the Netcare 911 HEMS operations.

Table 4.1: Districts from which cases were transported from by both HEMS operations

Districts from which case originated	Gauteng HEMS Operation			KwaZulu-Natal HEMS Operation		
	n	% within HEMS operation	% of Total Cases	n	% within HEMS operation	% of Total Cases
Alfred Nzo District Municipality	0	0.00%	0.00%	2	2.40%	0.40%
Amajuba District Municipality	2	0.40%	0.40%	7	8.50%	1.30%
Bojanala Platinum District Municipality	16	3.50%	3.00%	0	0.00%	0.00%
Capricorn District Municipality	3	0.70%	0.60%	0	0.00%	0.00%
City of Johannesburg Metropolitan Municipality	110	24.20%	20.50%	0	0.00%	0.00%
City of Tshwane Metropolitan Municipality	78	17.10%	14.50%	0	0.00%	0.00%
Dr Kenneth Kaunda District Municipality	4	0.90%	0.70%	0	0.00%	0.00%
Ehlanzeni District Municipality	4	0.90%	0.70%	0	0.00%	0.00%
Ekurhuleni Metropolitan Municipality	101	22.20%	18.80%	0	0.00%	0.00%
eThekwini Metropolitan Municipality	0	0.00%	0.00%	22	26.80%	4.10%
Fezile Dabi District Municipality	2	0.40%	0.40%	0	0.00%	0.00%
Gert Sibande District Municipality	10	2.20%	1.90%	0	0.00%	0.00%
Sekhukhune District Municipality	4	0.90%	0.70%	0	0.00%	0.00%
iLembe District Municipality	0	0.00%	0.00%	4	4.90%	0.70%
Ngaka Modiri Molema District Municipality	3	0.70%	0.60%	0	0.00%	0.00%
Nkangala District Municipality	14	3.10%	2.60%	0	0.00%	0.00%
Sedibeng District Municipality	41	9.00%	7.60%	0	0.00%	0.00%
Sisonke District Municipality	0	0.00%	0.00%	6	7.30%	1.10%
Ugu District Municipality	0	0.00%	0.00%	17	20.70%	3.20%
uMgungundlovu District Municipality	0	0.00%	0.00%	16	19.50%	3.00%
uMkhanyakude District Municipality	0	0.00%	0.00%	1	1.20%	0.20%
uMzinyathi District Municipality	0	0.00%	0.00%	1	1.20%	0.20%
uThukela District Municipality	0	0.00%	0.00%	3	3.70%	0.60%
uThungulu District Municipality	0	0.00%	0.00%	1	1.20%	0.20%
Waterberg District Municipality	15	3.30%	2.80%	0	0.00%	0.00%
West Rand District Municipality	48	10.50%	8.90%	0	0.00%	0.00%
Zululand District Municipality	0	0.00%	0.00%	2	2.40%	0.40%
TOTAL	**455**	**100.00%**	**84.70%**	**82**	**100.00%**	**15.30%**

Of the cases managed by the Gauteng HEMS operation, the most common districts within South Africa from which cases originated were the City of Johannesburg Metropolitan Municipality, which had 110 (24.2%); Ekurhuleni Metropolitan Municipality, which had 101 (22.2%); and the City of Tshwane Metropolitan Municipality, which had 78 (17.1%) of the total cases. The Gauteng HEMS operation also collected 2 (0.4%) patients from the Amajuba District Municipality which falls within the KwaZulu-Natal province. This is represented in Figure 4.2.

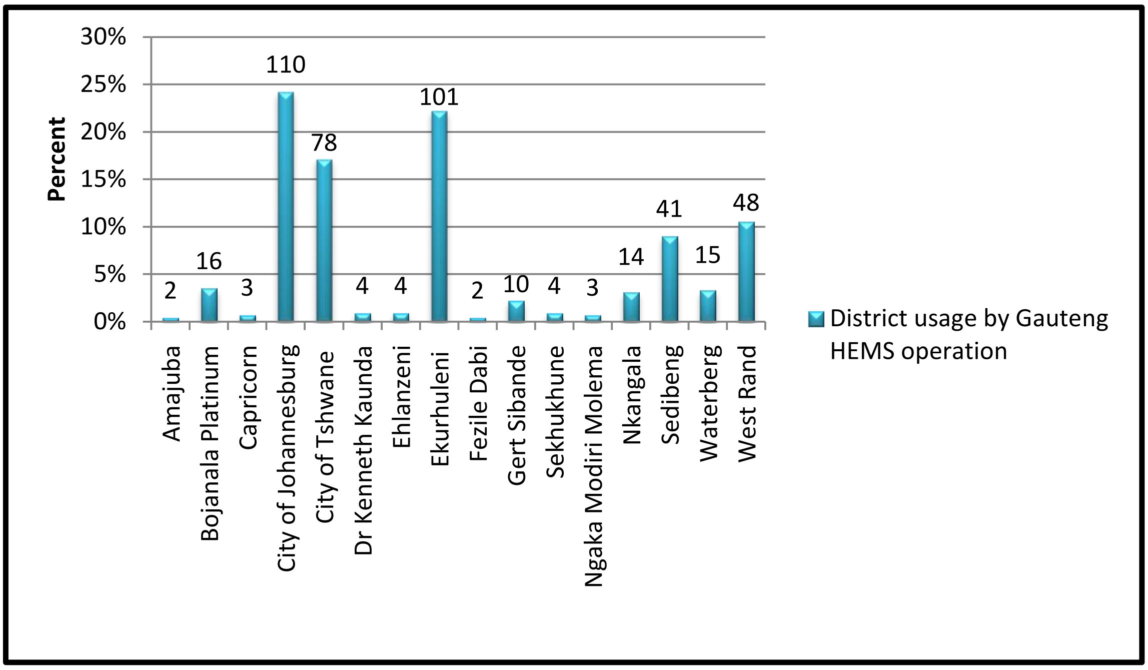


Figure 4.2: Districts from which cases were transported by the Gauteng HEMS operation

Figure 4.3 depicts the most common South African districts serviced by the KwaZulu-Natal HEMS operation. Within the province of KwaZulu-Natal, the most frequented district was the eThekwini Metropolitan Municipality, which had 22 (26.8%) cases; followed by Ugu District Municipality, which had 17 (20.7%) cases; and the uMgungundlovu District Municipality, which had 16 (19.5%) of the total cases. The KwaZulu-Natal HEMS operation also crossed over into the Eastern Cape to collect 2 (2.4%) patients from the Alfred Nzo District Municipality. These flights were from local medical centres in Bizana and Matatiele and both were inter-facility transfers.

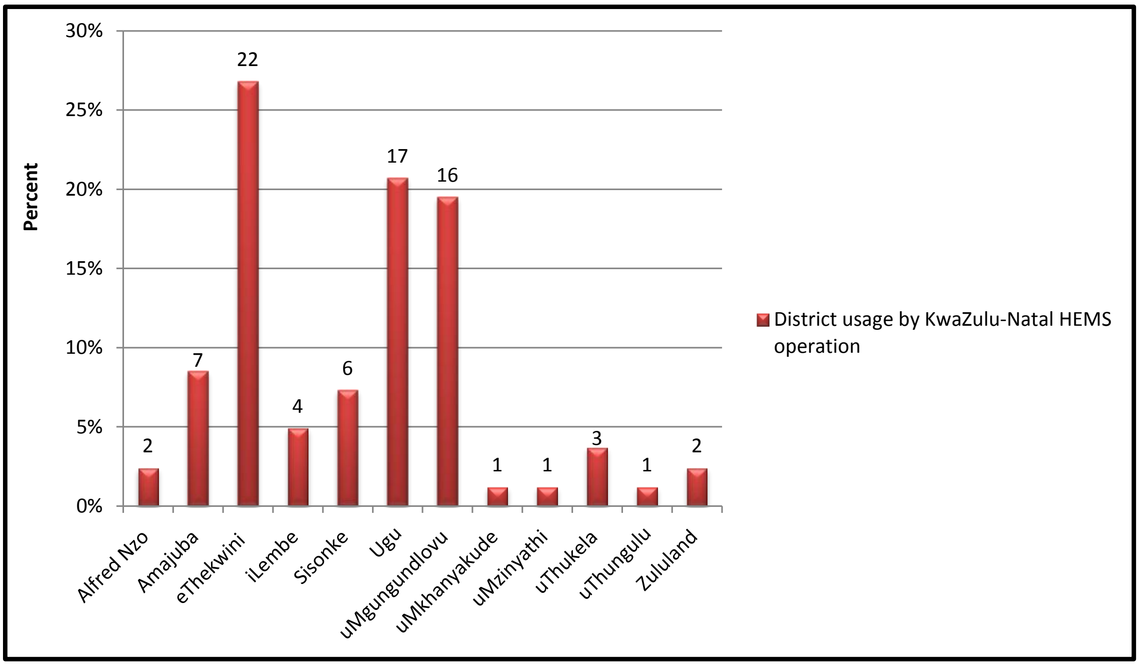


Figure 4.3: Districts from which cases were transported by the KwaZulu-Natal HEMS operation

4.3 Patient Demographics

The results that follow will address the demographics of the patients flown by the Netcare 911 HEMS operations.

4.3.1 Gender of patients transported

Cross tabulation was utilized to determine if there was any statistical significance in the gender of the cases transported by both of the HEMS operations. Of the 455 cases transported by the Gauteng HEMS operation, 350 (76.9%) were males and 105 (23.1%) were females and of the 82 cases transported by the KwaZulu-Natal HEMS operation, 48 (58.5%) were males and 34 (41.5%) were females. The value for the Fisher's Exact Test ($p = 0.001$) is less than the level of significance (p value < 0.05). This implies that there is a significant relationship between the gender of the patients transported and the HEMS operations. The percentages of females (Gauteng: 23.1% and KwaZulu-Natal: 41.5%) and males (Gauteng: 76.9%

and KwaZulu-Natal: 58.5%) are not similar in the two HEMS operations. The ratio of females to males in Gauteng was 1:3, whilst for KZN it was 1:1.5 (Figure 4.4).

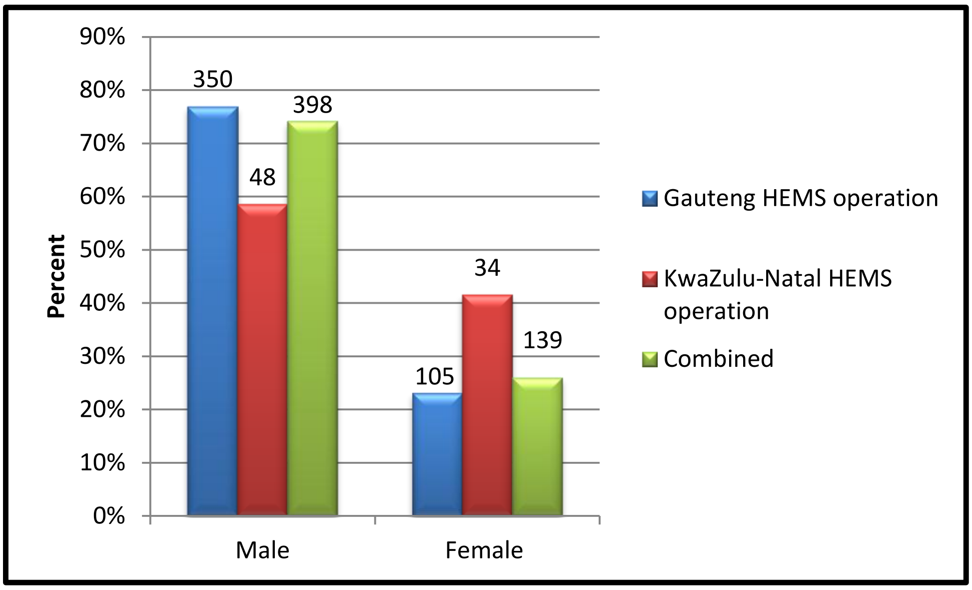


Figure 4.4: Gender of patients transported by the Gauteng and KwaZulu-Natal HEMS operations

4.3.2 Age of patients transported

Cross-tabulation was utilized to establish whether any relationship existed between the ages of the patients transferred and the different HEMS operations. Figure 4.5 shows the various age groups attended to by the different operations. Analysis of the records indicates that the majority of the cases transported by both operations were adults. Of the total 455 cases transported by the Gauteng operation, 364 (80.0%) were adults and of the 82 cases transported by the KwaZulu-Natal operation, 73 (89.0%) were adults. The Fisher's value ($p = < \text{than } 0.001$) is less than the level of significance (p value < 0.05); therefore there is a statistical significance in the difference in the age groups transported and the HEMS operations. The percentage of adult patients flown (Gauteng: 80.0% and KwaZulu-Natal: 89.0%) is significantly more than the percentage of paediatric (Gauteng: 15.2% and

KwaZulu-Natal: 7.3%), infant (Gauteng: 3.1% and KwaZulu-Natal: 2.4%) and neonatal (Gauteng: 1.8% and KwaZulu-Natal: 1.2%) patients flown by both of the HEMS operations.

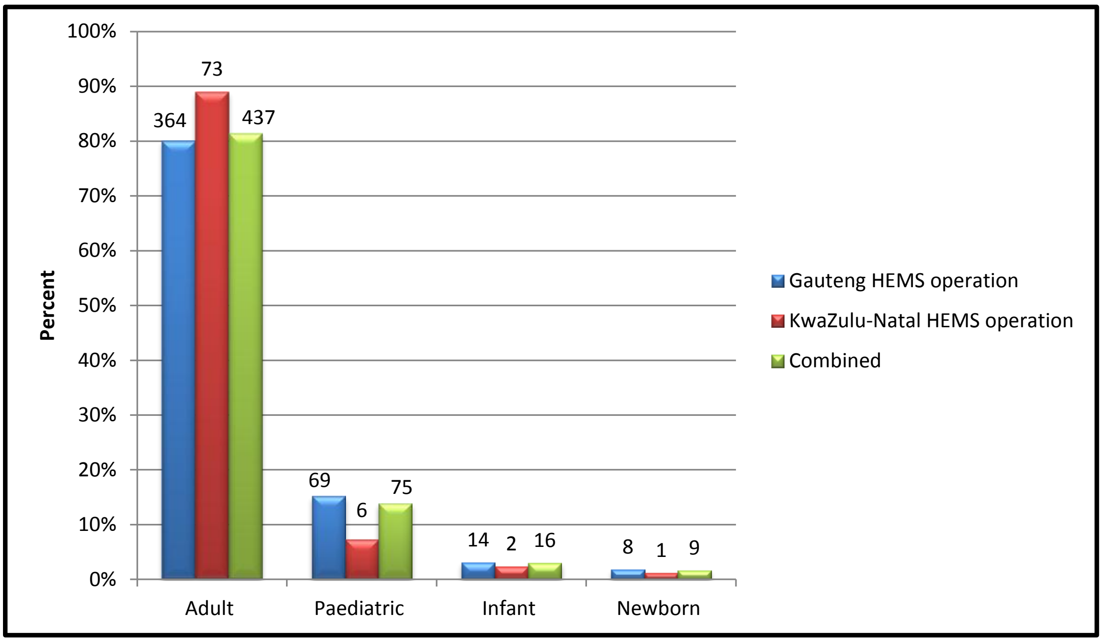


Figure 4.5: Age of patients transported by the Gauteng and KwaZulu-Natal HEMS operations

4.4 Dispatch Information

The dispatch information will address the results relating to the type of transfer, the billing options, type of incident as well as the authorization criteria utilized.

4.4.1 Type of transfer (primary or inter-facility)

With reference to the types of transfers that the HEMS operations were dispatched to, both of the HEMS operations were most frequently dispatched to primary transfers, which totalled to 357 (66.5%) of all the cases. The remaining cases were inter-facility transfers, which totalled to 180 (33.5%) cases. Figure 4.6 represents the transfer type combined for both HEMS operations.

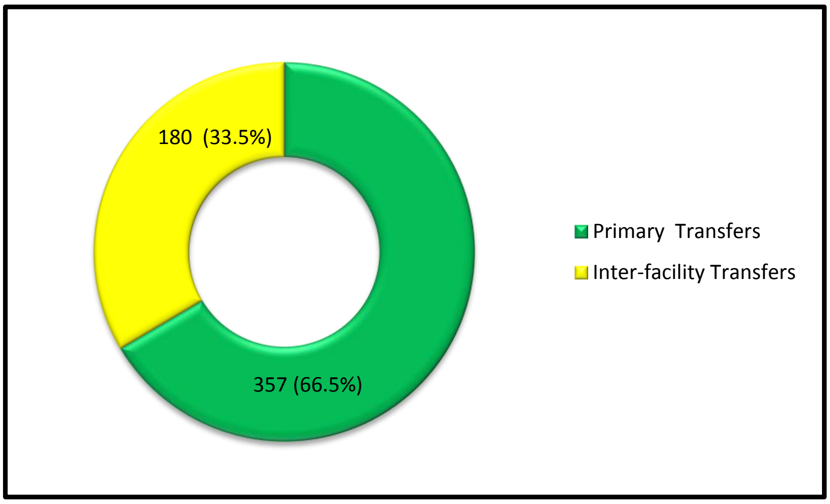


Figure 4.6: Transfer type for both HEMS operations

Figure 4.7 provides a more detailed breakdown of the number of primary transfers and inter-facility transfers in the two HEMS operations. Primary transfers made up the majority of the cases for both operations, with 306 (67.3%) in Gauteng and 51 (62.2%) in KwaZulu-Natal. The inter-facility transfers were the minority in both operations, with 149 (32.7%) in Gauteng and 31 (37.8%) in KwaZulu-Natal.

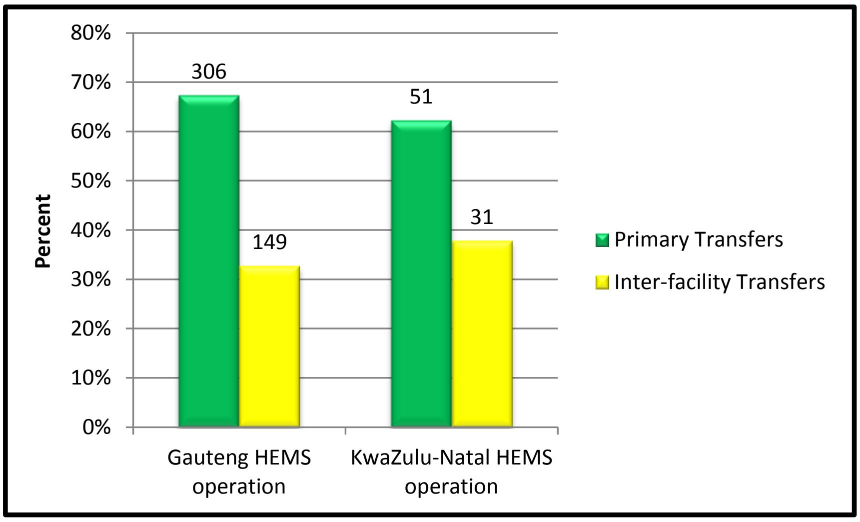


Figure 4.7: Transfer type for the Gauteng and KwaZulu-Natal HEMS operations

4.4.2 Relationship between the type of transfer and age group

Cross-tabulation was utilized to determine if there was any statistical significance in the type of transfer and the patient's age (p value < 0.05). Figure 4.8 shows the relationship between the type of transfer and the different age groups. The majority of the primary transfers were adult patients, with 310 (86.8%) cases and the remainder of the primary transfers consisted of 44 (12.3%) paediatrics and 3 (0.8%) infants. None of the primary transfers involved neonates. The majority of the inter-facility transfers were also adults, with 127 (70.6%) cases. The remaining inter-facility transfers consisted of 31 (17.2%) paediatrics, 13 (7.2%) infants and 9 (5.0%) neonates. No statistical significance was identified during this cross-tabulation.

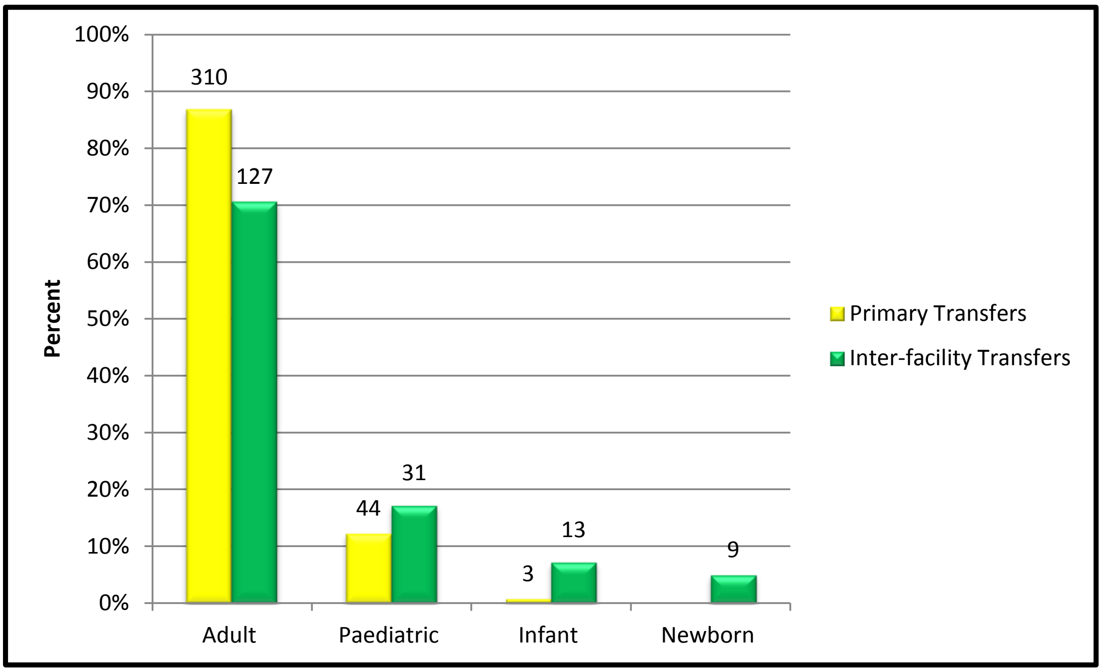


Figure 4.8: Age of patients transported in relation to the type of transfer

4.4.3 Billing Options

When analysing the billing options, as shown in Figure 4.9, a statistical significance was identified in the findings (p value < 0.05) utilizing the Fisher's Exact Test. The majority of the cases were authorized through medical aids (n= 272, 50.7%), followed by 207 (38.5%) of the cases being provincially authorised flights. A very small minority of cases were authorised through the Road Accident Fund (RAF) at 8 (1.5%) and Workmen's Compensation (WCA) at 50 (9.3%).

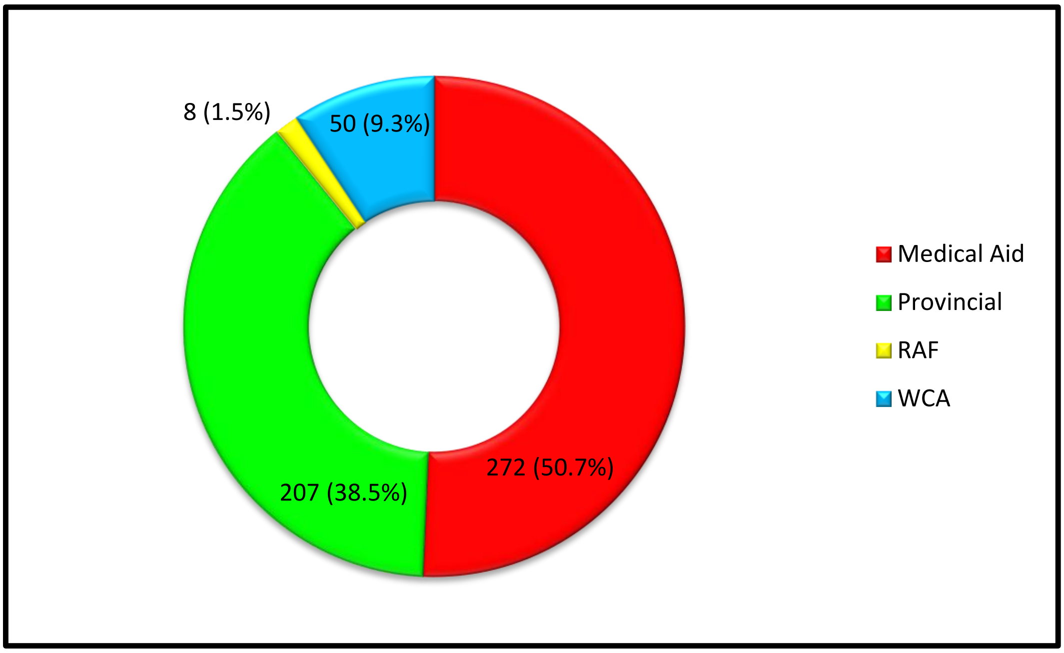


Figure 4.9: Billing options for both HEMS operations

By having a closer look at the billing options per HEMS operation in Figure 4.10 below, it is noted that KwaZulu-Natal had no cases which were authorised through the provincial route, yet the Gauteng operation had 207 (45.5%) provincial cases. Another notable difference is that the KwaZulu-Natal operation had 8 (9.8%) cases which were authorized through the Road Accident Fund, yet the Gauteng operation had none.

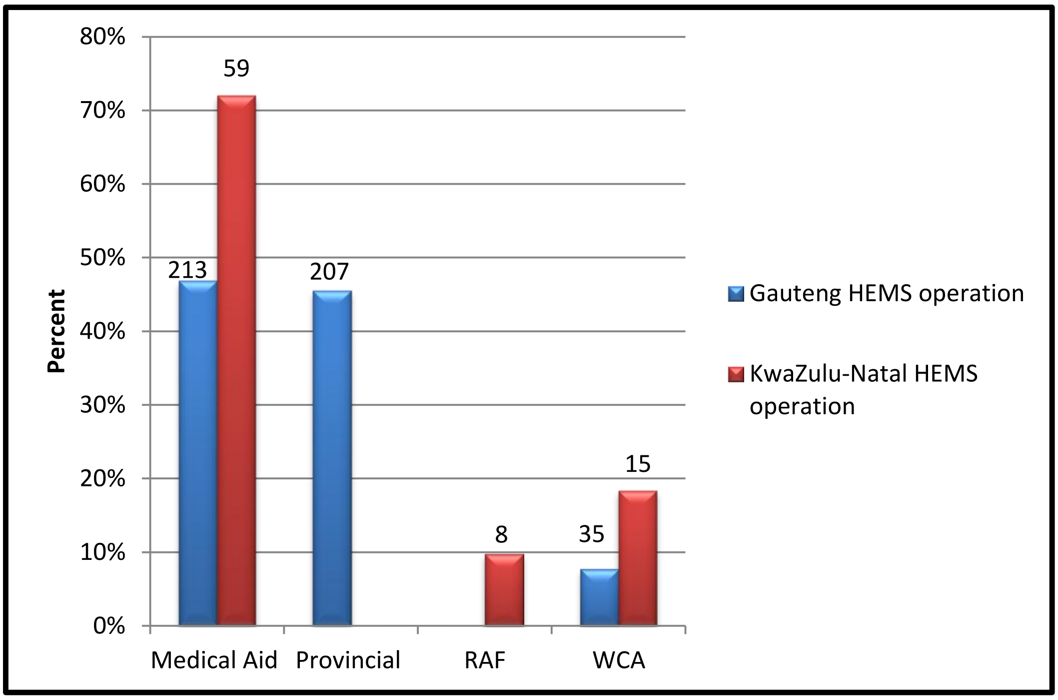


Figure 4.10: Billing options for the Gauteng and KwaZulu-Natal HEMS operations

4.4.4 Type of incidents

Table 4.2 is divided into three sections which show the types of incidents to which the Gauteng and KwaZulu-Natal HEMS operations were dispatched to as well as a combination for both of the operations. It can be seen that the most common incident type is motor vehicle accidents: Gauteng 168 (36.9%), KwaZulu-Natal 25 (30.50%), a combined number of 193 (36.0%). Pedestrian vehicle accidents were also very common: Gauteng 67 (14.7%), KwaZulu-Natal 2 (2.4%), a combined number of 69 (12.9%). When examining non-trauma related incident types, cardiac cases were the most frequently attended to: Gauteng: 21 (4.6%), KwaZulu-Natal 16 (19.5%) and combined 37 (6.9%).

Table 4.2: Type of incidents attended to by both HEMS operations

Types of Incidents	Gauteng HEMS Operation			KwaZulu-Natal HEMS Operation			Combined	
	n	% within HEMS operation	% of Total Cases	n	% within HEMS operation	% of Total Cases	n	% of Total Cases
Motor vehicle accident	168	36.90%	31.30%	25	30.50%	4.70%	193	36.00%
Pedestrian vehicle accident	67	14.70%	12.50%	2	2.40%	0.40%	69	12.90%
Cardiac	21	4.60%	3.90%	16	19.50%	3.00%	37	6.90%
Shooting	26	5.70%	4.80%	5	6.10%	0.90%	31	5.70%
Burns	26	5.70%	4.80%	0	0.00%	0.00%	26	4.80%
Motor bike accident	18	4.00%	3.40%	3	3.70%	0.60%	21	4.00%
Unknown medical	12	2.60%	2.20%	5	6.10%	0.90%	17	3.10%
Falls	11	2.40%	2.00%	4	4.90%	0.70%	15	2.70%
Other	15	3.10%	3.00%	0	0.00%	0.00%	15	3.00%
Respiratory disorder	10	2.20%	1.90%	4	4.90%	0.80%	14	2.70%
Drowning / near-drowning	13	2.90%	2.40%	0	0.00%	0.00%	13	2.40%
Domestic accident	10	2.20%	1.90%	0	0.00%	0.00%	10	1.90%
Industrial accident	8	1.70%	1.50%	2	2.40%	0.40%	10	1.90%
Assault	9	2.00%	1.70%	0	0.00%	0.00%	9	1.70%
Neonatal transfer	8	1.80%	1.50%	0	0.00%	0.00%	8	1.50%
Vascular	7	1.50%	1.30%	1	1.20%	0.20%	8	1.50%
CVA	5	1.10%	0.90%	1	1.20%	0.20%	6	1.10%
Fall from a horse	3	0.70%	0.60%	2	2.40%	0.40%	5	1.00%
Seizures	2	0.40%	0.40%	3	3.70%	0.60%	5	1.00%
Burns & Industrial Accident	4	0.80%	0.80%	0	0.00%	0.00%	4	0.80%
Obstetrics	3	0.70%	0.60%	1	1.20%	0.20%	4	0.80%
Medical - other	3	0.60%	0.60%	0	0.00%	0.00%	3	0.60%
Cardiac & Renal	0	0.00%	0.00%	2	2.40%	0.40%	2	0.40%
Cardiac & Respiratory disorder	1	0.20%	0.20%	1	1.20%	0.20%	2	0.40%
Snake bite	1	0.20%	0.20%	1	1.20%	0.20%	2	0.40%
Boat accident	0	0.00%	0.00%	1	1.20%	0.20%	1	0.20%
Cardiac & Vascular	0	0.00%	0.00%	1	1.20%	0.20%	1	0.20%
Neonatal transfer & Respiratory Disorder	0	0.00%	0.00%	1	1.20%	0.20%	1	0.20%
Neonatal transfer, Cardiac & Sepsis	1	0.20%	0.20%	0	0.00%	0.00%	1	0.20%
Renal	1	0.20%	0.20%	0	0.00%	0.00%	1	0.20%
Scuba diving accident	0	0.00%	0.00%	1	1.20%	0.20%	1	0.20%
Sepsis	1	0.20%	0.20%	0	0.00%	0.00%	1	0.20%
Shooting & Assault	1	0.20%	0.20%	0	0.00%	0.00%	1	0.20%
TOTAL	**455**		**84.70%**	**82**		**15.30%**	**537**	**100.00%**

4.4.5 Type of incident related to billing option

Cross-tabulation was utilized to determine if there was any statistically significant relationship between the type of incidents to which the HEMS operations were dispatched and the different billing options. No statistical significance could be identified as motor vehicle accidents appeared to be the most prevalent incident type in all of the different billing options.

Figure 4.11 depicts the incident types in medical aid cases. The most common incident type was motor vehicle accidents, making up 75 (27.6%) of the medical aid cases. The next most notable category were the cardiac cases, which totalled to 37 (13.6%) of the cases. The category titled “other” is a combination of a number of different incident types where the total numbers were too insignificant to represent independently.

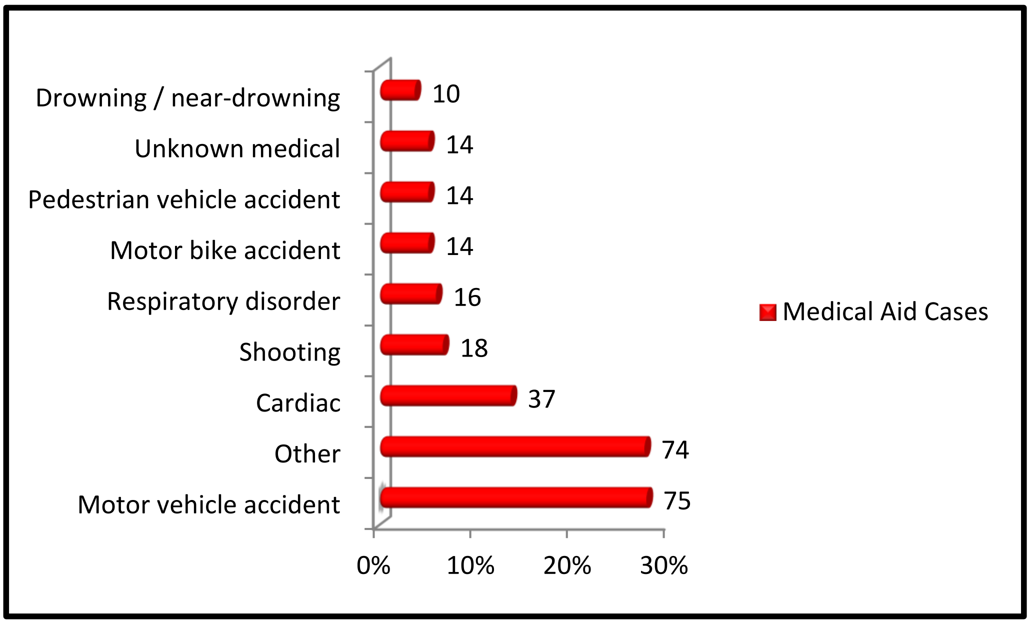


Figure 4.11: Incident type in medical aid cases

The provincially authorised cases are represented in Figure 4.12. Once again, motor vehicle accidents were the most frequently attended to incident type with the total being 95 (45.9%) of the provincially authorised cases. The next most frequent incident type for provincial cases was pedestrian vehicle accidents: 50 (24.2%).

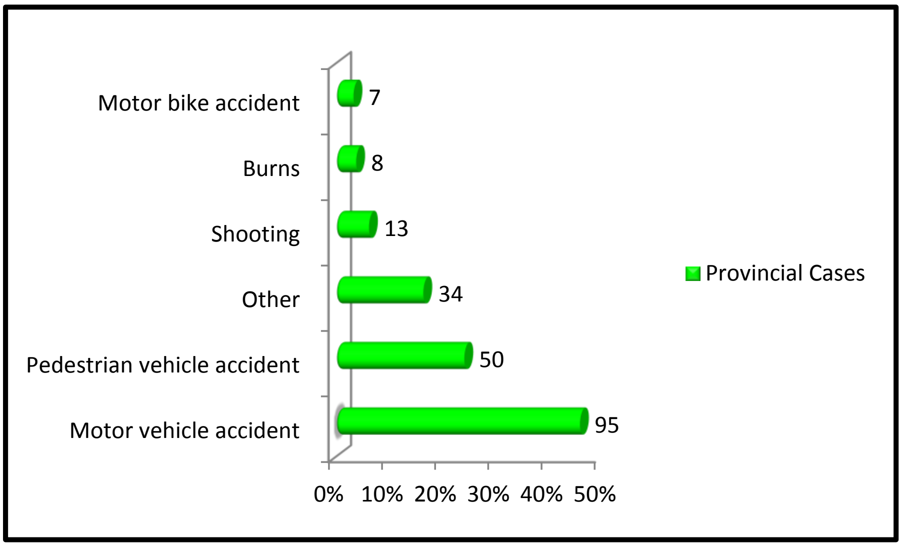


Figure 4.12: Incident type in provincial authorisation cases

Figure 4.13 represents the cases that were authorised through the Road Accident Fund (RAF). Only the KwaZulu-Natal HEMS operation utilized RAF authorisation for cases. The two different incident types which were authorised by the RAF were 6 (75.0%) motor vehicle accidents and 2 (25.0%) pedestrian vehicle accidents.

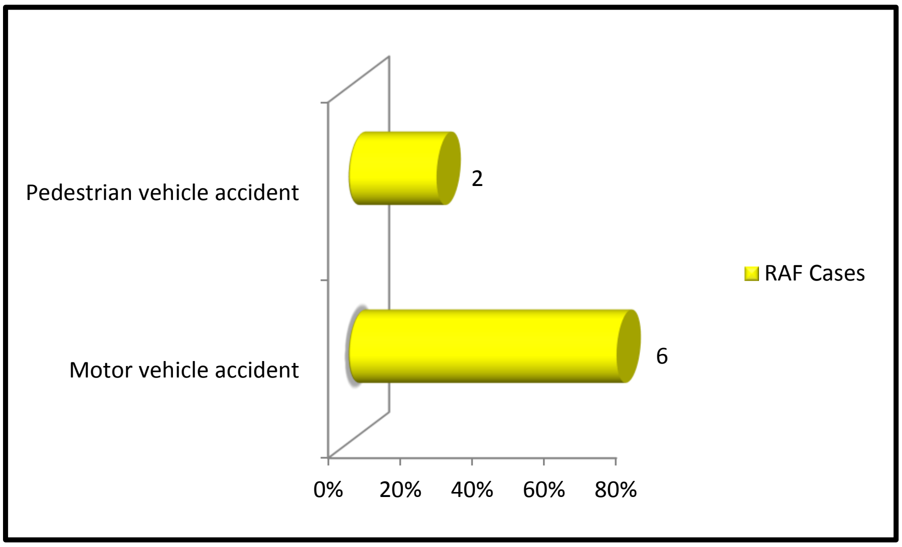


Figure 4.13: Incident type in RAF cases

Cases which were authorised through Workmen's Compensation (WCA) are represented in Figure 4.14. Motor vehicle accidents were again the most frequent incident type authorised through WCA: 17 (34.0%). The category titled "other" included 1 (2.0%) shooting, 1 (2.0%) assault, 1 (2.0%) domestic accident, 1 (2.0%) fall from a horse and 1 (2.0%) snake bite.

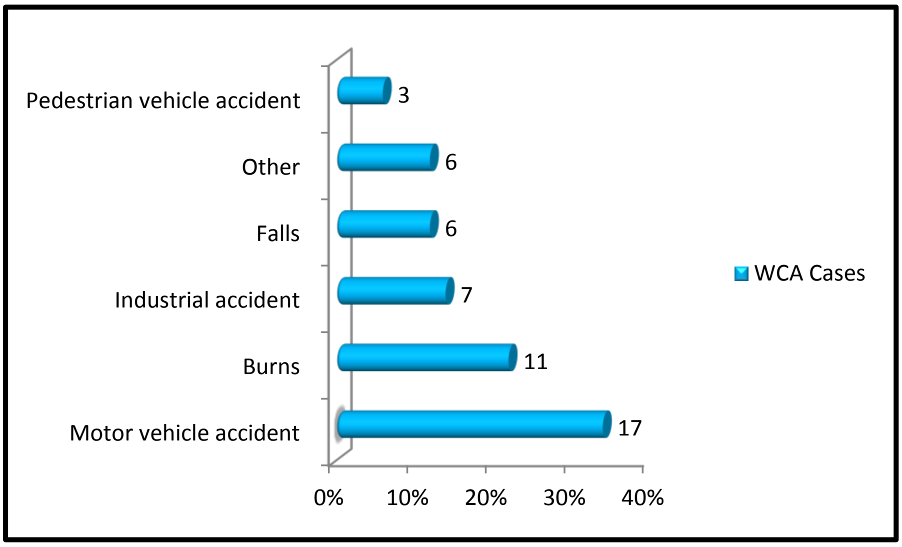


Figure 4.14: Incident type in WCA cases

4.4.6 Authorisation Criteria Utilized

Table 4.3 shows the frequency at which both of the HEMS operations were dispatched utilizing the different HEMS authorisation criteria approved by Netcare 911. Many of the cases were authorized utilizing multiple criteria. As is evident from the data presented below, the two most common reasons for authorising the helicopters were life threatening medical conditions that require urgent interventions that are unavailable in the local facility and isolated head injury where the Glasgow Coma Scale (GCS) is between 5 and 12. When combining the authorisation criteria for both of the HEMS operations, 155 (17.51%) of the cases were authorised based on the criteria "life threatening medical conditions that require urgent intervention that is unavailable in the local facility". However, the most frequently utilised authorisation criteria for the Gauteng HEMS operation was for a patient with an “isolated head injury where the GCS is between 5 and 12” (n= 127, 17.14%), whereas for the KwaZulu-Natal HEMS operation, the most frequently utilised authorisation criteria was “life threatening medical conditions that require urgent intervention that is unavailable in the local facility” (n= 35, 24.31%).

Table 4.3: Authorisation criteria utilized for authorisation of transfers

Authorisation Criteria	Gauteng HEMS Operation		KwaZulu-Natal HEMS Operation		Combined	
	n	% within HEMS operation	n	% within HEMS operation	n	% of Total Authed
Life threatening medical conditions that require urgent intervention that is unavailable in the local facility	120	16.19%	35	24.31%	155	17.51%
Isolated head injury where the GCS is between 5 and 12	127	17.14%	10	6.94%	137	15.48%
Where specialized equipment or expertise carried by the helicopter is required on scene	87	11.74%	19	13.19%	106	11.98%
Initial blood pressure of less than 80 mmHg systolic	68	9.18%	5	3.47%	73	8.25%
Where signs and symptoms indicate a spinal injury and road transportation time exceeds 20 minutes or where terrain prevents safe ground transport	57	7.69%	15	10.42%	72	8.14%
Where ALS is required and cannot be delivered by road in a reasonable time period	45	6.07%	17	11.81%	62	7.01%
Patients with respiratory distress despite supplemental oxygen	42	5.67%	7	4.86%	49	5.54%
Head injury with focal neurological fallout	44	5.94%	2	1.39%	46	5.20%
Severe penetrating injury trauma to head, neck, thorax and/or abdomen with possible involvement of the underlying organs or vascular structures	33	4.45%	4	2.78%	37	4.18%
Mass casualty incidents where the local EMS resources are greatly	28	3.78%	7	4.86%	35	3.95%
Burns: In adults with 20-80% BSA	28	3.78%	1	0.69%	29	3.28%
Unstable myocardial infarction	7	0.94%	13	9.03%	20	2.26%
Amputations: Above knee or elbow with significant vascular compromise	15	2.02%	1	0.69%	16	1.81%
Near drowning with neurological deficit or haemodynamic compromise	12	1.62%	0	0.00%	12	1.36%
Neonatal emergencies requiring urgent upgrade in care to a Neonatal ICU or Neonatologist	10	1.35%	1	0.69%	11	1.24%
Burns to face, neck, chest with airway compromise	7	0.94%	0	0.00%	7	0.79%
Hypothermia (<35 deg Celsius) or hyperthermia (>40 deg Celsius)	5	0.67%	0	0.00%	5	0.56%
Where access to the scene is limited but a helicopter can safely be landed	1	0.13%	4	2.78%	5	0.56%
Unstable arrhythmias	2	0.27%	2	1.39%	4	0.45%
Refractory seizures	2	0.27%	1	0.69%	3	0.34%
Burns: In children with >10% BSA	1	0.13%	0	0.00%	1	0.11%

4.5 Time frames

The time frames will be reported on in the following sub-sections.

4.5.1 Mean time frames

Table 4.4 reflects the mean time frames representing the flying time to scene, on-scene time, flying time to hospital and total mission time. The mean flying time to the scene (Gauteng: 0:21:00.66 and KwaZulu-Natal: 0:42:10.24) and the mean flying time from scene to hospital (Gauteng: 0:14:37.85 and KwaZulu-Natal: 0:33:30.37) were longer in the KwaZulu-Natal HEMS operation missions when compared to the Gauteng HEMS operation. The mean on-scene time is very similar for both operations (Gauteng: 0:30:46.68 and KwaZulu-Natal: 0:32:20.00).

Table 4.4: Mean time frames

	Gauteng HEMS Operation			
	Mean	**Standard Deviation**	**Median**	**IQR**
Flying time to scene incident	0:21:00.66	0:18:35.52		
On scene time	0:30:46.68	0:26:57.95		
Flying time to hospital	0:14:37.85	0:53:19.37	0:12:00.00	0:10:00.00
Total mission time	1:55:49.05	0:59:44.01		
	KwaZulu-Natal HEMS Operation			
	Mean	**Standard Deviation**	**Median**	**IQR**
Flying time to scene incident	0:42:10.24	0:29:46.46		
On scene time	0:32:20.00	0:21:47.67		
Flying time to hospital	0:33:30.37	0:27:12.84		
Total mission time	2:34:40.98	1:10:19.76		
	Combined			
	Mean	**Standard Deviation**	**Median**	**IQR**
Flying time to scene incident	0:24:14.53	0:22:01.08		
On scene time	0:31:00.78	0:26:14.25		
Flying time to hospital	0:17:28.99	0:50:41.34	0:13:00.00	0:12:00.00
Total mission time	2:01:45.14	1:02:58.33		

4.5.2 Mean on-scene time frames for different transfer types

When comparing the mean on-scene times in both primary and inter-facility transfers, no statistical significance was identified (Table 4.5). The mean on-scene time for primary transfers was 0:30:37.42 and for inter-facility transfers was 0:31:46.99.

Table 4.5: Mean on-scene time frames

		On Scene Time	
Type of Transfer	**n**	**Mean**	**Standard Deviation**
Primary Transfers	357	0:30:37.42	0:26:29.05
Inter-facility Transfers	180	0:31:46.99	0:25:47.92

4.6 Clinical procedures

The analysis of the reports revealed that a number of clinical procedures had been performed by the aeromedical crew of both HEMS operations. This section presents a breakdown of the clinical procedures performed by the aeromedical crew and documented as such on the EPRF. Many of the patients transported by the Netcare 911 HEMS operations had a number of clinical procedures performed and medications administered during their transport to hospital.

4.6.1 Clinical procedures – airway management

Figure 4.15 represents all of the clinical procedures related to airway management documented on the EPRFs by the aeromedical crew. Oral intubation was the most commonly performed airway management procedure, with 97 (16.8%) oral endotracheal intubations being performed on the primary transfers and 34 (5.9%) on inter-facility transfers. However, the majority of patients (n=390, 67.7%) required no airway management.

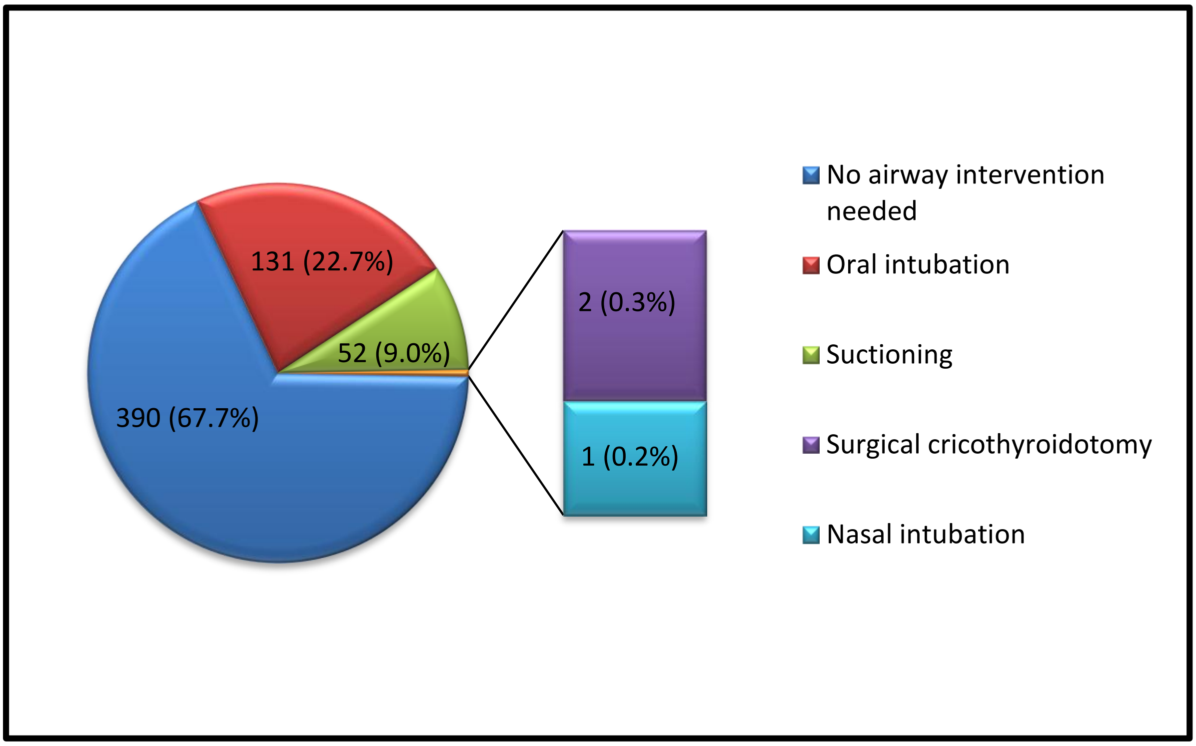


Figure 4.15: Airway clinical procedures

4.6.2 Clinical procedures – breathing management

The clinical procedures related to the management of breathing are represented in Figure 4.16. The most commonly performed clinical procedure was bag-valve-tube ventilation on 203 (35.9%) of the patients transported. Intercostal drains were inserted in 6 (1.1%) of the patients transported by the HEMS operations, with 5 (0.9%) of these being inserted on primary transfers and only 1 (0.2%) during an inter-facility transfer. Intercostal drains as a clinical procedure form part of the medical doctor's scope of practice. Emergency Care Practitioner's and ALS paramedics are not able to perform this specific clinical procedure.

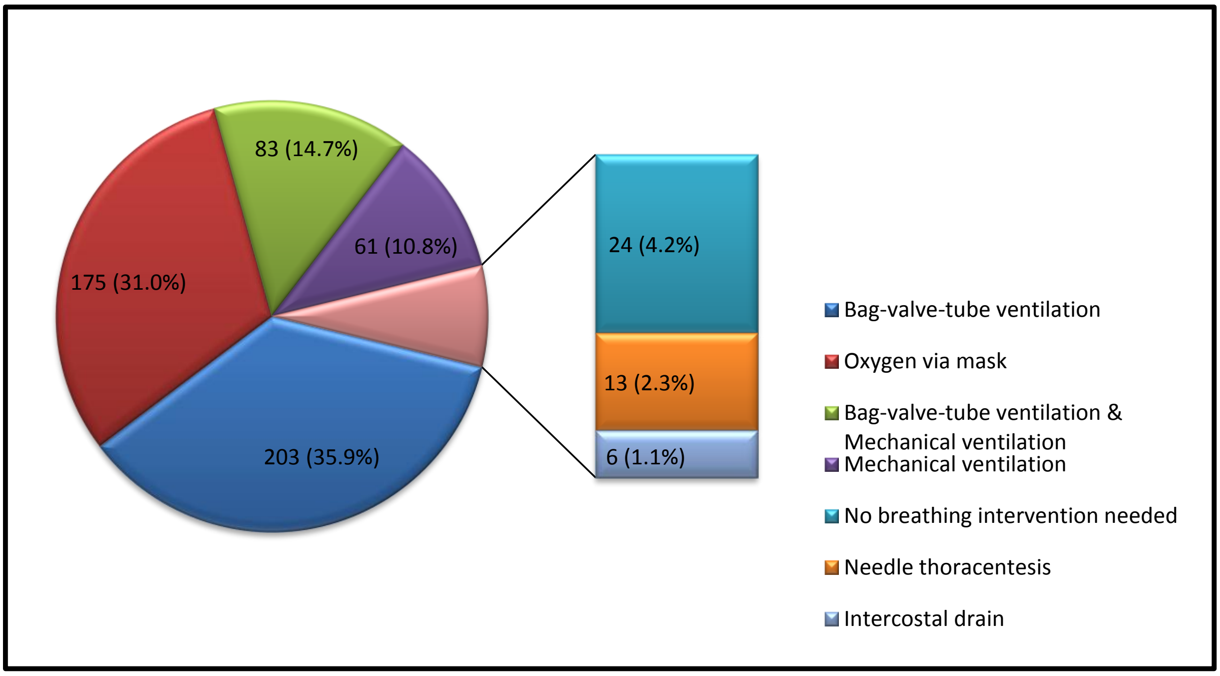


Figure 4.16: Breathing clinical procedures

4.6.3 Clinical procedures - circulation management

Figure 4.17 represents specific clinical procedures performed by the aeromedical crew to manage circulatory concerns. Peripheral venous cannulation was the most frequently performed circulatory clinical procedure: 257 (43.6%). The "other" circulatory skills included: 16 (2.7%) cardiopulmonary resuscitations, 15 (2.5%) intraosseous cannulations, 15 (2.5%) central venous access, 14 (2.4%) fluid resuscitations, 9 (1.5%) external jugular vein cannulations, 9 (1.5%) femoral vein cannulations and 3 (0.5%) patients required no circulation interventions. Out of the 15 patients who had central venous access sited, 5 (0.8%) were primary transfers and 10 (1.7%) were inter-facility transfers. Central venous access as a clinical procedure forms part of the medical doctor's scope of practice. Emergency Care Practitioner's and ALS paramedics are not able to perform this clinical procedure.

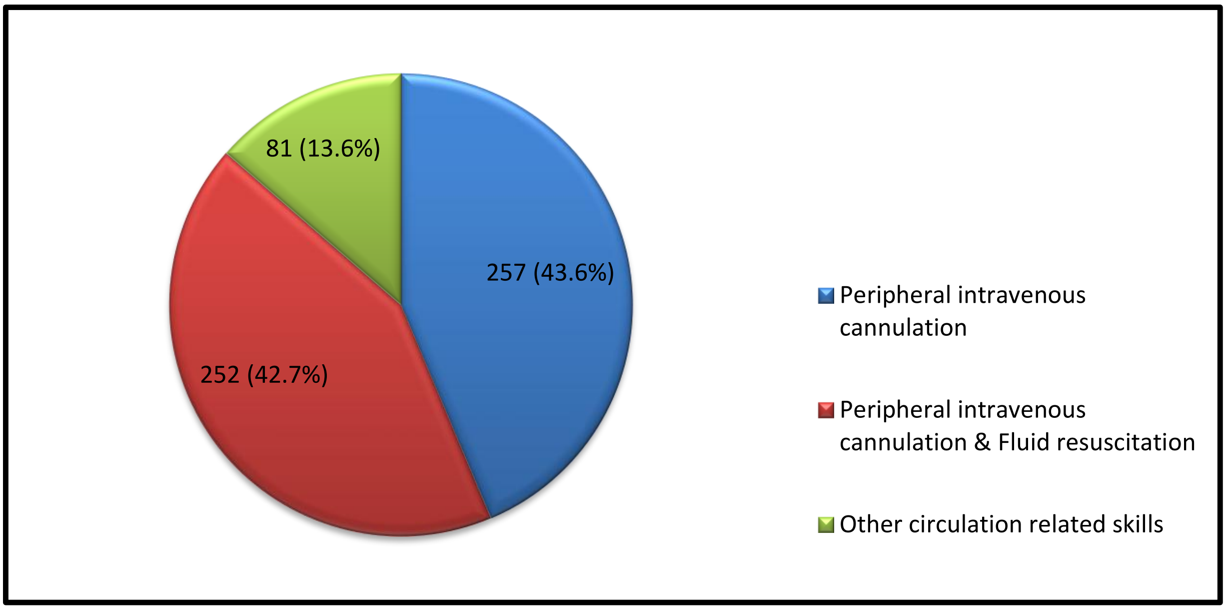


Figure 4.17: Circulation clinical procedures

4.6.4 Clinical procedures - non-specific

A number of non-specific clinical procedures were performed by the aeromedical crew during the transportation of the 537 patients (Figure 4.18). Full spinal immobilisation was the most commonly performed non-specific clinical procedure: 402 (40.0%). Some of the less frequently performed non-specific clinical skills included: 17 (1.7%) urinary catheter insertions, 15 (1.5%) nasogastric tube insertions, 13 (1.3%) incubator transfers, 10 (1.0%) splinting of fractures, 9 (0.9%) orogastric tubes, 3 (0.3%) defibrillations, 3 (0.3%) transcutaneous pacing, 1 (0.1%) capnography and 1 (01%) patient required no other interventions.

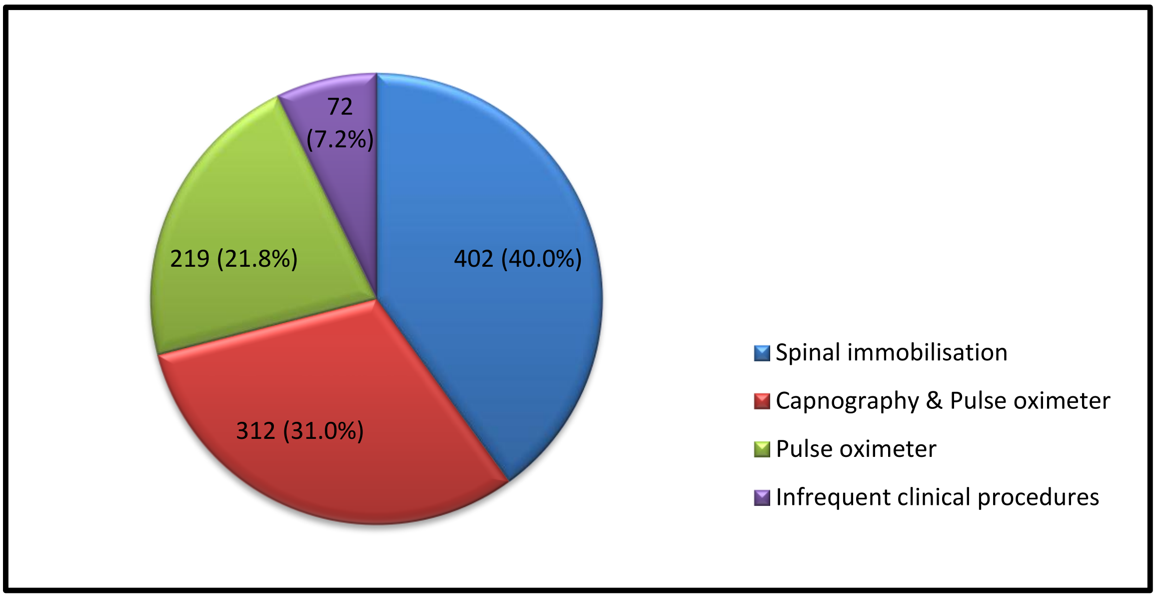


Figure 4.18: Non-specific clinical procedures

4.6.5 Pharmacology

The EPRF system listed all the medications that had been administered to the patients who had been transported by the two Netcare 911 HEMS operations. Figure 4.19 gives a breakdown of all of the medications administered to the patients by the aeromedical crew during the 12 month study period. The most common medication was a combination of Morphine and Midazolam, which was administered to 192 (20.0%) of the patients transported. Other commonly utilised medications included Suxamethonium Chloride (n=100, 10.4%) and Etomidate (n=82, 8.6%). The aeromedical crew administered no medications to 134 (14.0%) of the patients transported.

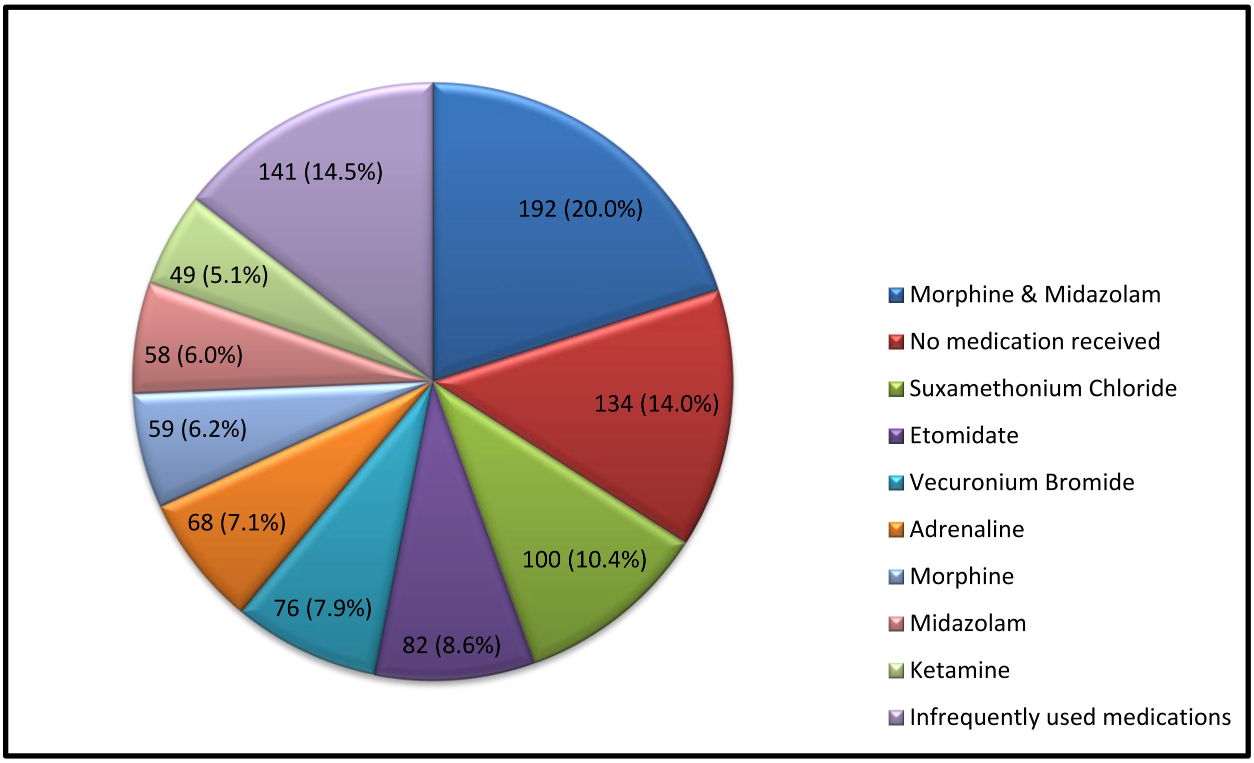


Figure 4.19: Medications administered

4.6.6 Clinical procedures performed and medications administered on different transfer types

Cross tabulation was utilized to determine whether any relationship existed between the clinical procedures performed by the aeromedical crew on the different transfer types. No statistical significance was identified. The data reflected in Figure 4.20 shows that the majority of the clinical procedures were performed by the aeromedical crew during the primary transfers: 384 (66.6%) airway clinical procedures, 378 (67.0%) breathing clinical procedures, 393 (66.6%) circulation clinical procedures, 683 (68.0%) non-specific clinical procedures and 629 (65.6%) medications administered. Fewer clinical procedures were performed during the inter-facility transfers: 192 (33.3%) airway clinical procedures, 187 (33.0%) breathing clinical procedures, 197 (33.4%) circulation clinical procedures, 322 (32.0%) non-specific clinical procedures and 330 (34.4%) medications administered.

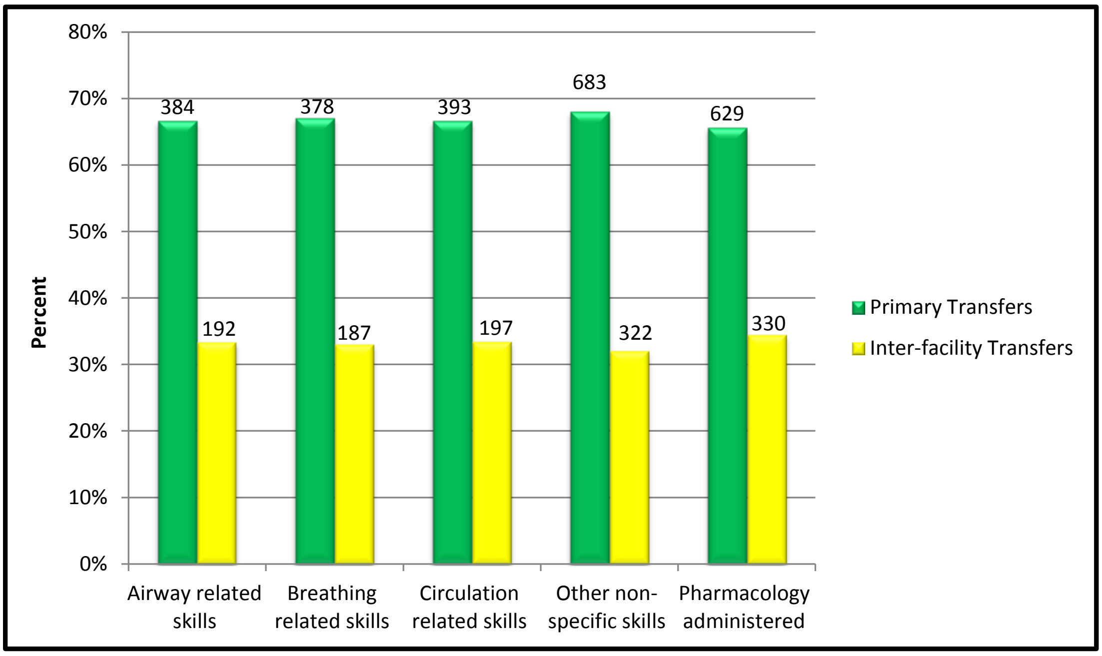


Figure 4.20: Clinical procedures performed on primary and inter-facility transfers

Figure 4.21 has an in-depth look at the pharmacological management of the patients by the aeromedical crew in relation to the crew's scope of practice. During patient management by the aeromedical crew, 519 (96.1%) of the medications that were administered during the primary transfers fell within the ECP scope of practice, and 21 (3.9%) fell outside of the ECP scope. With the inter-facility transfers, 237 (83.2%) of the medications administered fell within the ECP scope, and 48 (16.8%) fell outside of the ECP scope. Some of the medications that fell outside of the ECP scope of practice included: Dobutamine, Dopamine, Fentanyl Citrate, Insulin, Nitrocine, Pancuronium Bromide, Phenylephrine, Phenytoin Sodium, Prochlorperazine, Propofol, Rosuvastatin and Sodium Valproate.

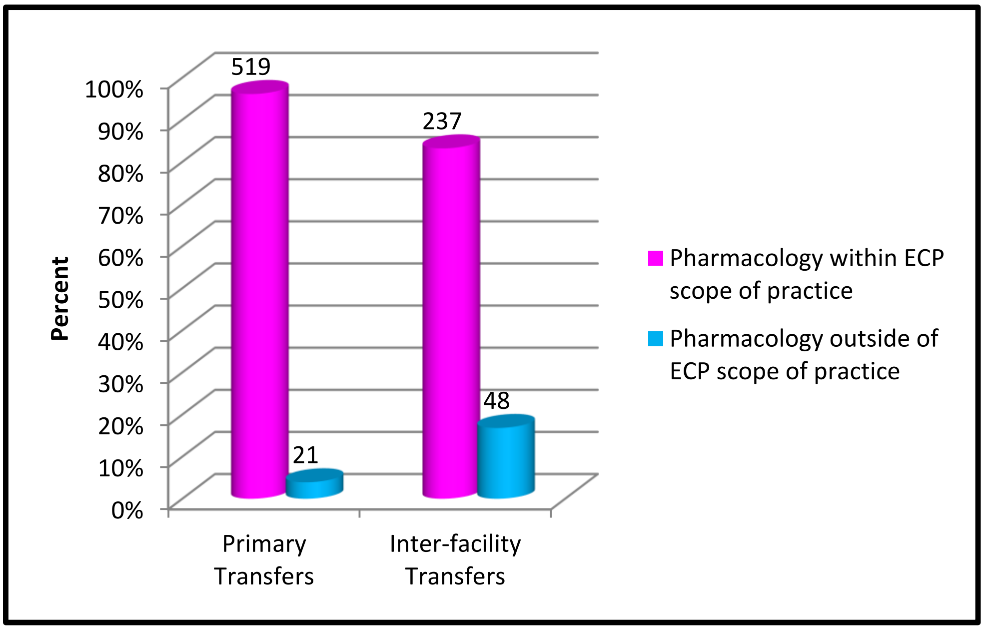


Figure 4.21: Medications relating to ECP scope and transfer type

4.7 Patient Outcome

The patient outcome after 24 and 72 hours will be addressed in the following section.

4.7.1 Patient outcome after 24 hours

Cross tabulation of the data showed that 339 (63.1%) of the patients were alive and stable at the time of the 24 hour follow up assessment. Sixty-six (n=66, 12.3%) of the patients were deceased and 10 (1.9%) had been discharged. The Fisher's value ($p = 0.049$) is less than the level of significance (p value < 0.05); therefore there is a statistically significant relationship. A breakdown of patient outcome with respect to the Gauteng HEMS operation showed that 280 (61.5%) of the patients were alive and stable, 110 (24.2%) were alive and unstable, 58 (12.7%) were deceased and 7 (1.5%) had been discharged. When reviewing the data from the KwaZulu-Natal HEMS operation: 59 (72.0%) of the patients were alive and stable, 12 (14.6%) were alive and unstable, 8 (9.8%) were deceased and 3 (3.6%) had been discharged (Figure 4.22).

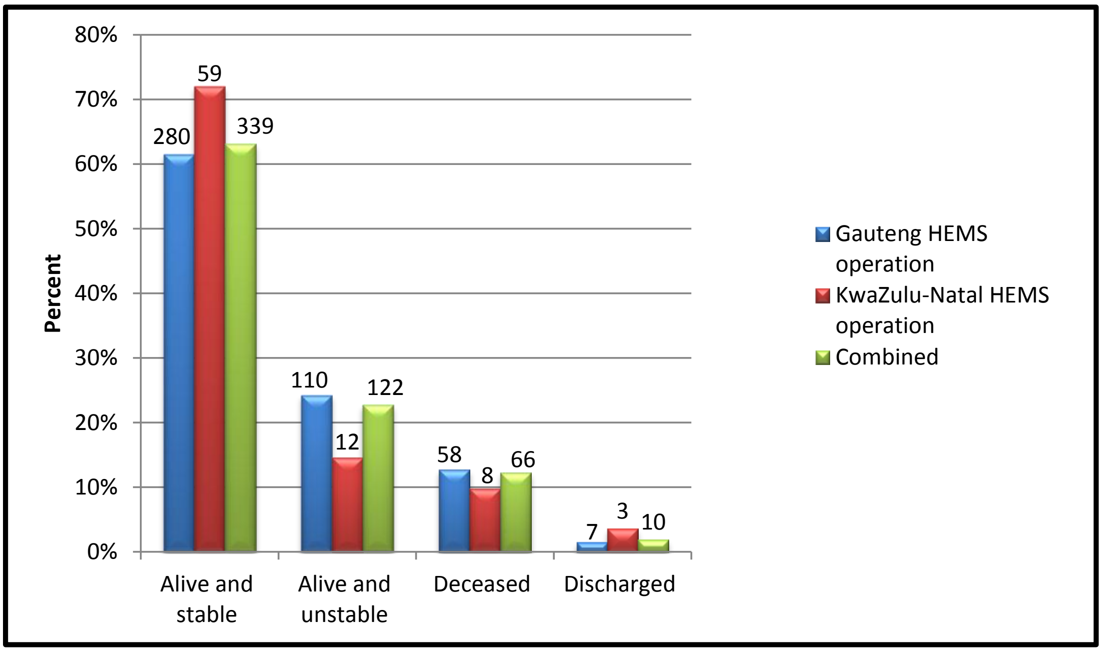


Figure 4.22: Patient outcome after 24 hours

4.7.2 Patient outcome after 72 Hours

Once again, cross tabulation of the data confirmed that the majority (404 (75.3%)) of the patients who had been transported by both services were alive and stable at the 72 hour follow-up assessment (Figure 4.23). With respect to the Gauteng HEMS operation: 345 (75.8%) of the patients were alive and stable, 63 (13.8%) were alive and unstable, 20 (4.4%) were deceased and 27 (5.9%) had been discharged. When reviewing the data from the KwaZulu-Natal HEMS operation, 59 (72.0%) of the patients were alive and stable, 7 (8.5%) were alive and unstable, 6 (7.3%) were deceased and 10 (12.2%) had been discharged.

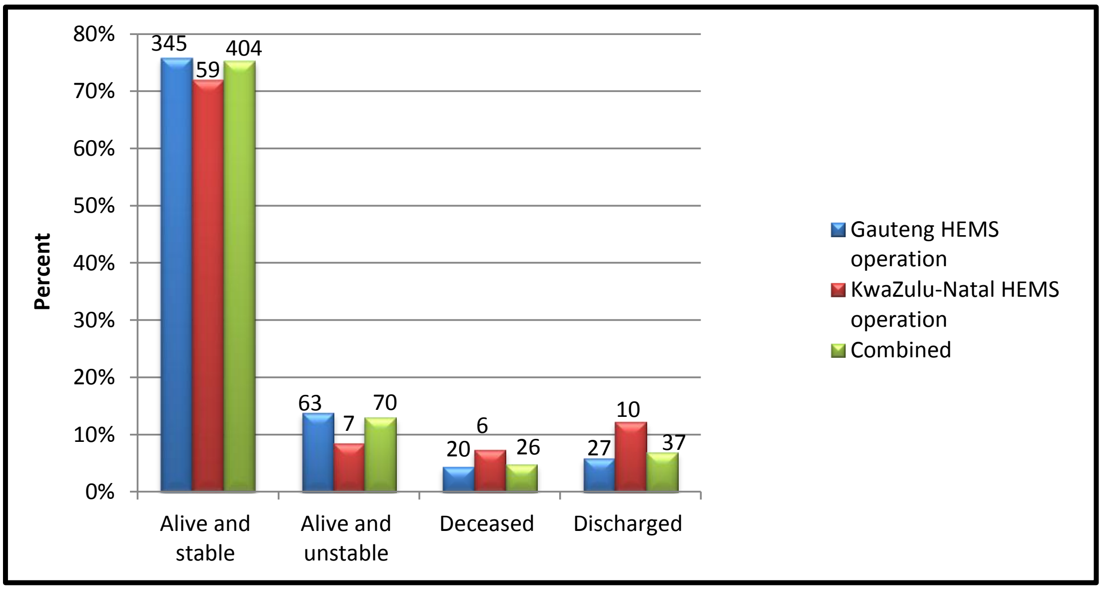


Figure 4.23: Patient outcome after 72 hours

4.7.3 Patient outcome at 24 hours in relation to incident type

Cross-tabulation was performed in an attempt to establish whether any relationships existed between the types of incidents the helicopters were dispatched to and the patient outcome at the 24 hour follow up assessment (Table 4.6). No significance was found when applying the Pearson's Chi-Square test (p value < 0.05). Table 4.6 is divided into four sections that represent the patient outcome at 24 hours: 1) alive and stable, 2) alive and unstable, 3) deceased and 4) discharged. At the 24 hour follow up assessment, 123 (22.91%) of the patients involved in a motor vehicle accident were alive and stable, 38 (7.08%) were alive and unstable, 28 (5.21%) were deceased and 4 (0.74%) had been discharged. Likewise, 38 (7.08%) of the patients involved in a pedestrian vehicle accident were alive and stable, 18 (3.35%) were alive and unstable, 13 (2.42%) were deceased and none had been discharged.

Table 4.6: Type of incident related to patient outcome at 24 hours

Type of Incident	PATIENT OUTCOME AFTER 24 HOURS							
	Alive and stable		Alive and unstable		Deceased		Discharged	
	n	% of Total Count	n	% of Total Count	n	% of Total Count	n	% of Total Count
Motor vehicle accident	123	22.91%	38	7.08%	28	5.21%	4	0.74%
Pedestrian vehicle accident	38	7.08%	18	3.35%	13	2.42%	0	0.00%
Cardiac	27	5.03%	8	1.49%	1	0.19%	4	0.80%
Shooting	17	3.17%	6	1.12%	9	1.68%	0	0.00%
Motor bike accident	16	2.98%	4	0.74%	1	0.19%	0	0.00%
Burns	14	2.61%	11	2.05%	3	0.56%	0	0.00%
Respiratory disorder	11	2.05%	4	0.74%	2	0.37%	0	0.00%
Other	11	2.05%	4	0.74%	0	0.00%	0	0.00%
Falls	10	1.86%	4	0.74%	1	0.19%	0	0.00%
Industrial accident	10	1.86%	1	0.19%	1	0.19%	0	0.00%
Drowning / near-drowning	8	1.49%	5	0.93%	0	0.00%	0	0.00%
Unknown medical	7	1.30%	6	1.12%	4	0.74%	0	0.00%
Vascular	7	1.30%	1	0.19%	0	0.00%	0	0.00%
Neonatal transfer	7	1.30%	1	0.19%	0	0.00%	0	0.00%
Assault	6	1.12%	2	0.37%	1	0.19%	0	0.00%
Domestic accident	6	1.12%	2	0.37%	0	0.00%	2	0.37%
Fall from a horse	4	0.74%	0	0.00%	1	0.19%	0	0.00%
Obstetrics	4	0.74%	0	0.00%	0	0.00%	0	0.00%
Seizures	3	0.56%	2	0.37%	0	0.00%	0	0.00%
Medical - other	3	0.56%	1	0.19%	0	0.00%	0	0.00%
Renal	2	0.37%	0	0.00%	0	0.00%	0	0.00%
Snake bite	2	0.37%	0	0.00%	0	0.00%	0	0.00%
Scuba diving accident	1	0.19%	0	0.00%	0	0.00%	0	0.00%
Sepsis	1	0.19%	0	0.00%	0	0.00%	0	0.00%
Boat accident	1	0.19%	0	0.00%	0	0.00%	0	0.00%
CVA	0	0.00%	4	0.74%	1	0.19%	0	0.00%
TOTAL	**339**	**63.13%**	**122**	**22.72%**	**66**	**12.29%**	**10**	**1.92%**

4.7.4 Patient outcome at 72 hours in relation to incident type

A similar attempt was made to establish whether any relationships existed between the types of incidents the helicopters were dispatched to and the patient outcome after 72 hours by performing a cross-tabulation (Table 4.7). The Fisher's value (< than 0.001) is less than the level of significance (p value < 0.05); therefore there is a statistically significant relationship. Table 4.7 is also divided into four sections that represent the patient outcome at 72 hours: 1) alive and stable, 2) alive and unstable, 3) deceased and 4) discharged. At the 72 hour follow up assessment, 156 (29.05%) of the patients involved in a motor vehicle accident were alive and stable, 22 (4.10%) were alive and unstable, 9 (1.68 %%) were deceased and 6 (1.12%) had been discharged. Similarly, 54 (10.06%) of the patients involved in a pedestrian vehicle accident were alive and stable, 9 (1.68%) were alive and unstable, 4 (0.74%) were deceased and 2 (0.37%) had been discharged.

Table 4.7: Type of incident related to patient outcome at 72 hours

Type of Incident	PATIENT OUTCOME AFTER 72 HOURS							
	Alive and stable		Alive and unstable		Deceased		Discharged	
	n	% of Total Count	n	% of Total Count	n	% of Total Count	n	% of Total Count
Motor vehicle accident	156	29.05%	22	4.10%	9	1.68%	6	1.12%
Pedestrian vehicle accident	54	10.06%	9	1.68%	4	0.74%	2	0.37%
Shooting	29	5.40%	3	0.56%	0	0.00%	0	0.00%
Cardiac	24	4.47%	4	0.74%	3	0.56%	9	1.68%
Burns	19	3.54%	7	1.30%	2	0.37%	0	0.00%
Motor bike accident	18	3.35%	2	0.37%	0	0.00%	1	0.19%
Respiratory disorder	13	2.42%	2	0.37%	1	0.19%	1	0.19%
Unknown medical	12	2.23%	3	0.56%	0	0.00%	2	0.37%
Industrial accident	11	2.05%	1	0.19%	0	0.00%	0	0.00%
Other	10	1.86%	3	0.56%	1	0.19%	1	0.19%
Assault	8	1.49%	1	0.19%	0	0.00%	0	0.00%
Vascular	7	1.30%	0	0.00%	1	0.19%	0	0.00%
Neonatal transfer	7	1.30%	1	0.19%	0	0.00%	0	0.00%
Falls	6	1.12%	2	0.37%	2	0.37%	5	0.93%
Drowning / near-drowning	6	1.12%	3	0.56%	1	0.19%	3	0.56%
Domestic accident	5	0.93%	1	0.19%	0	0.00%	4	0.74%
Fall from a horse	4	0.74%	0	0.00%	0	0.00%	1	0.19%
Obstetrics	4	0.74%	0	0.00%	0	0.00%	0	0.00%
Seizures	3	0.56%	2	0.37%	0	0.00%	0	0.00%
Renal	2	0.37%	0	0.00%	0	0.00%	0	0.00%
Medical - other	2	0.37%	2	0.37%	0	0.00%	0	0.00%
Scuba diving accident	1	0.19%	0	0.00%	0	0.00%	0	0.00%
Sepsis	1	0.19%	0	0.00%	0	0.00%	0	0.00%
Snake bite	1	0.19%	0	0.00%	0	0.00%	1	0.19%
CVA	1	0.19%	2	0.37%	2	0.37%	0	0.00%
Boat accident	0	0.00%	0	0.00%	0	0.00%	1	0.19%
TOTAL	**404**	**75.23%**	**70**	**13.04%**	**26**	**4.84%**	**37**	**6.89%**

4.8 Conclusion

In this chapter, the results of the statistical tests on the collected data have been presented and briefly discussed in relation to the purpose and objectives of the study. The following chapter will provide an in depth interpretation and discussion of the results as they apply to the purpose and objectives of this study.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter will provide a detailed discussion of the results from the previous chapter and all findings will be placed into the context of existing literature in the field.

5.2 Clinical Demographics of Patients Transported

5.2.1 Call Volume

In total, 537 cases were attended to by both of the HEMS operations during the 12 month study period. Of the 537 cases, 455 (84.7%) cases were managed by the Gauteng HEMS operation and 82 (15.3%) by the KwaZulu-Natal HEMS operation. It is clear that there was a significant difference in the call volume of the two HEMS operations ($p = < 0.05$: CI 99%). However, there are operational differences between the two HEMS operations that would impact on the call volume and activity levels.

The Netcare 911 HEMS operation in Gauteng is a 24 hour operation that is functional during day and night hours, while the KwaZulu-Natal operation was only a daylight service, which limited its amount of available flying hours. Furthermore, the changes in season have an impact on the number of daylight hours available to transport patients. Daylight hours flying is restricted to a set time period which is 45 minutes before and after sunset (*Civil aviation authority* 2013). According to Part 138 from the Civil Aviation Authority, a helicopter that is registered for ambulance operations may not embark on any flights at night unless the helicopter in use is certified for instrument flight and it is operated in accordance for instrument flight. The reduced flying hours for the KwaZulu-Natal operation may have contributed to the reduced number of cases in KwaZulu-Natal. Another factor which may have impacted on the higher call volume in Gauteng was the geographical location of the calls. The Netcare 911 Gauteng HEMS operation attended to a number of incidents outside of the Gauteng province, whereas the KwaZulu-Natal operation mainly attended to incidents within the province. The KwaZulu-Natal HEMS operation only attended to two (2) cases in the Eastern Cape.

As was reflected in the previous chapter, the cases managed by the Netcare 911 HEMS operation required authorization through four different methods. These four methods of call authorization were: 1) Medical Aid; 2) Provincial; 3) Road Accident Fund and 4) Work Compensation. The provincial authorisation process is one which is tendered for in each provincial area and only the Gauteng operation was able to fly patients through the provincial authorisation process. This difference was also one of the main reasons for the significant difference in cases managed by each of the operations.

5.2.2 Incident Location

The results of the study showed that certain districts within Gauteng and KwaZulu-Natal were a lot busier than other districts. Interestingly, the busier districts were more centrally located in the urban areas for both of the operations. In Gauteng the busiest districts were: 1) City of Johannesburg Metropolitan Municipality (n=110; 24.2%); 2) Ekurhuleni Metropolitan Municipality (n=101; 22.2%); and 3) City of Tshwane Metropolitan Municipality (n=78; 17.1%). With reference to KwaZulu-Natal, the busier districts were: 1) eThekwini Metropolitan Municipality (n=22; 26.8%); 2) Ugu District Municipality (n=17; 20.7%); and 3) uMgungundlovu District Municipality (n=16; 19.5%).

Although HEMS operations are very expensive to implement and operate, there are certain situations in which helicopters are seen as an acceptable transport resource (Taylor *et al.* 2010). This is specifically true for isolated areas either due to rural location or traffic congestion (Stratton 2013). The Netcare 911 HEMS operations appear to have transported most of their patients from urban areas that are in close proximity to Level one facilities.

The reasons behind this could possibly be related to traffic congestion. However, this could not be confirmed as the time of day of these cases was not recorded as part of this study. Certain logistical and geographical situations such as severe traffic congestion may support HEMS transportation in an urban setting, but it is unwarranted in most cases (Brown and Gestring 2013).

There have been a number of studies focusing on the benefit of HEMS operations and there is much debate as to whether HEMS offers any benefit in the urban setting. The study by Brown and Gestring (2013) reported that urban patients transported by HEMS have longer pre-hospital times than those transported by GEMS and also that less than 23% of patients transported by HEMS in an urban setting benefited from this costly service (Brown and Gestring 2013).

Furthermore, a number of studies have determined that transporting a patient by helicopter is not always faster than a GEMS operation. A HEMS operation is usually only faster over distances greater than 45km, in poor road conditions and when traffic conditions are congested (Melton *et al.* 2007). A study undertaken by Mommsen et al (2012) confirmed this finding by determining that if a flight distance is less than 35 to 40km, then the utilization of a HEMS operation no longer appears to arrive at the incident significantly earlier than the nearest GEMS operation (Mommsen *et al.* 2012).

Both the Gauteng and KwaZulu-Natal HEMS operations attended to incidents in rural areas outside of their provinces. The Gauteng HEMS operation attended to cases in the North West, Free State, Limpopo and Mpumulanga provinces as well as to two cases in the Amajuba district municipality, which lies within the KwaZulu-Natal Province. Both of these were inter-facility transfers and the receiving hospitals with the specialist requirements were based in Gauteng. The KwaZulu-Natal HEMS operation also attended to two cases in the Alfred Nzo district municipality, which is in the Eastern Cape. These were also inter-facility transfers.

In many of the rural areas, the emergency medical services are under-resourced and the medical personnel on scene have to decide on the most suitable resource to utilize to transport patients to the most appropriate facility with minimal delay. This decision involves making a choice between GEMS and HEMS and a number of implications have to be taken into account. HEMS operations are able to cover larger distances in a faster time than GEMS operations and the HEMS operations are usually staffed with more experienced medical personnel, such as medical doctors and emergency care practitioners. However, HEMS operations are much more costly than GEMS. Furthermore, GEMS operations are more widely available and can generally be at the scene of an incident fairly quickly. The staffing of GEMS vehicles can vary quite significantly in their level of expertise. Therefore, if the vehicle is staffed by less qualified personnel, life-saving interventions might be delayed if the incident is a fair distance away from an appropriate hospital (Stewart *et al.* 2011). Using the HEMS in such circumstances can be justified. Helicopters also have the advantage of having the option of bypassing closer district hospitals in an attempt to locate the most appropriate facility for definitive care (Hardcastle 2011).

5.2.3 Patient Demographics – Gender and Age

The findings revealed that the majority of the patients transported by the Netcare 911 HEMS operations were male adults. With respect to gender, the records showed that a total of 398 (74.1%) male patients had been transported as opposed to 139 (25.9%) female patients. The number of male patients was statistically significant as the p value was < 0.05. This appears to be in line with international trends, although many of the studies only included patients over the age of 15 years (Cudnik *et al.* 2012; Giannakopoulos *et al.* 2013). In a study conducted in Ohio which included a total of 557 patients, the majority of the patients were male (67%) (Cudnik *et al.* 2012). A study was conducted on a Dutch HEMS located at the VU University Medical Centre in Amsterdam over a six year period. During this time period a total of 446 patients were transported and the majority of these patients were male (n=331; 74.2%) (Giannakopoulos *et al.* 2013).

The analysis also showed that the majority of patients transported in both Gauteng and KwaZulu-Natal were adults, with 437 (81.4%) adult patients flown as compared to only 75 (13.9%) paediatric patients, 16 (3.0%) infants and 9 (1.7%) neonates. Statistical significance was identified with the number of adult patients transported as the p value was < 0.05.

Various other studies have had similar findings. A study was conducted in KwaZulu-Natal in 1997 on another aeromedical service. Of the 398 patients that were transported during the 12 month study period, there were almost double the amount of male patients (63%) than female patients (33%). While the age distribution included patients of all ages, the majority of patients were mostly below 50 years of age with a mild peak between 21 and 40 years (Johnson and Dimopoulos 1998). Shepard et al (2008) described the activity of a HEMS operation based in rural north-western New South Wales over a three year period. In total, 171 patient care records were included in the study, of which 112 (65.5%) were men and 59 (34.5%) were woman. The patients' ages ranged from 6 months to 82 years, with a mean age of 39 years (standard error of the mean 1.55; median 38 years) (Shepherd *et al.* 2008).

A five year study was conducted at the Delaware HEMS operation. Of the 969 patients who were transported during this period, 819 (84.5%) were adults and 143 (14.8%) were paediatrics. Due to incomplete patient records, seven patients (0.7%) were excluded as their age was unknown (Kotch and Burgess 2002).

A more recent study was undertaken involving a HEMS operation in Richards Bay, KwaZulu-Natal. This study included patients of all ages and findings showed that 797 (61.9%) adult patients were flown during the five year study period as opposed to only 194 (15.1%) paediatrics and 278 (21.6%)

neonates (D'Andrea, Van Hoving and Smith 2014). The findings in this study relating to gender and age are comparable to the results of the current study as adult and male patients were the predominant finding in both studies.

5.2.4 Transfer Type

The Netcare 911 HEMS operations attended to 357 (66.5%) primary responses and 180 (33.5%) inter-facility transfers during the study period with primary responses being the most prevalent type of transfer in both provinces: 306 (67.3%) in the Gauteng operation and 51 (62.2%) in the KwaZulu-Natal operation. The Gauteng operation had 149 (32.7%) inter-facility transfers and the KwaZulu-Natal operation had 31 (37.8%).

In the other local study focusing on the HEMS operation in Richards Bay, the reverse was found as inter-facility transfers made up the majority of the cases attended to. Out of a total of 1 418 flights, 1 253 (88.4%) were inter-facility transfers and only 165 (11.6%) were primary responses (D'Andrea, Van Hoving and Smith 2014).

The data collected for the current study demonstrated that the majority of patients transported from primary responses were adults (n=310; 86.8%) followed by paediatrics (n=44; 12.3%) and infants (n=3; 0.8%). There were no neonates transported. However, although adults also formed the majority of inter-facility transfers (n=127; 70.6%), findings showed that more infants and neonates were transferred by helicopter from one facility to another than primary responses, with 31 (17.2%) paediatrics, 13 (7.2%) infants and 9 (5.0%) neonates.

Many of the international studies focused on either primary transfers or inter-facility transfers and there were limited studies which included both. There were differing opinions on the potential benefits of HEMS operations for inter-facility transfers. One study determined that there is insufficient evidence available at this stage to determine the immediate benefits of HEMS over GEMS transportation for inter-facility transfers (Schwartz, Jacobs and

Yaezel 1989), whilst another study determined that the utilization of HEMS to transport patients for inter-facility transfers appears to provide a time benefit as it reduces transport time (Brown and Gestring 2013).

5.2.5 Billing Options

One of the biggest challenges researchers have faced when attempting to perform any research on HEMS operations is the different way in which the services operate from country to country. This includes criteria such as billing options, crew qualifications and clinical procedures. The civilian HEMS services function differently from country to country and usually fall within one of the following operating models: a) government funded, b) traditional model, c) fee-for-service, d) community based model or from e) public donations (Wikipedia 2013a). The Netcare 911 HEMS operation utilizes a mix of these operating models.

The Netcare 911 HEMS operation has four different billing options for patients transported: medical aid, provincial authorisation, road accident fund and workmen’s compensation. The medical aid cases are funded by the patient’s medical aid scheme, and all of these flights require pre-authorization from the various medical aid service providers. The Netcare 911 Gauteng HEMS operation is also utilized by the Gauteng Department of Health for the transportation of critically ill indigent patients. The majority of the service delivered to the Gauteng Department of Health involves the transport of patients from the pre-hospital environment to the nearest appropriate facility. This is not an exclusive relationship as it is shared with ER24 and RCAMS. The Netcare 911 KwaZulu-Natal HEMS operation did not have any contractual arrangements with the provincial government to transport indigent patients.

The Road Accident Fund is liable for providing appropriate cover to all road users within South Africa. The purpose of this cover is to rehabilitate and compensate persons injured in motor vehicle accidents whether they are

South African citizens or not (*Road accident fund* 2011). The main purpose of worker's compensation is to provide guaranteed remuneration for an employee who is temporarily or permanently unable to work due to an accident or health-related reason causally related to their work (Workers' compensation in the Republic of South Africa 2008).

The medical aid authorisations made up the majority of the cases attended to by both operations and the results were statistically significant (p value < 0.05). The Netcare 911 Gauteng HEMS operation transported 213 (46.8%) medical aid patients and the KwaZulu-Natal HEMS operation transported 59 (72.0%). When analysing the provincially authorised cases, the Gauteng HEMS operation attended to 207 (45.5%) cases. As there was no provincial government agreement in place for the KwaZulu-Natal operation, there were no provincially authorised cases. Interestingly, even although both HEMS operations had the opportunity to authorise cases through the road accident fund, only the KwaZulu-Natal HEMS operation attended to 8 (9.8%) cases.

5.2.6 Incident Type

The results of this study reflected that the most common type of incident to which the helicopter was dispatched were motor vehicle accidents (n=193, 36.0%). This finding is in line with a number of international studies (Galvagno *et al.* 2012; Hassani *et al.* 2012; McQueen *et al.* 2013). Patients involved in motor vehicle accidents may present with some of the time sensitive pathologies such as traumatic haemorrhage, polytrauma and traumatic brain injury. Cardiac cases (n=37, 6.9%) were the most commonly attended to non-traumatic incident by both of the Netcare 911 HEMS operations.

One of the main benefits of utilizing a HEMS operation to transport patients is the apparent shorter transport times. Although this is seen as one of the main benefits, there are a few others to consider when authorizing flights: 1) the aeromedical crew can provide a higher level of care when compared to

GEMS in terms of equipment and medical expertise, 2) the helicopter is able to access environments which cannot be accessed by GEMS and 3) the helicopter is able to transport the patient directly to a specialized trauma centre (Butler, Anwar and Willett 2010; Sullivent, Faul and Wald 2011). When determining which incident types and patients would potentially benefit from the utilisation of a HEMS operation, one must consider these main advantages.

As speed is seen as one of the major advantages of HEMS operations, it is essential that the incident types attended to would potentially benefit from the faster service in order to justify the added cost. Some of the time sensitive pathologies identified in previous studies include: traumatic haemorrhage, ST-elevation myocardial infarction, polytrauma, traumatic brain injury, burns, stroke and paediatric emergencies (Mommsen *et al.* 2012; Floccare *et al.* 2013). Polytrauma patients and patients with neurological injuries also appear to benefit the most from doctor based pre-hospital care (Giannakopoulos *et al.* 2013).

5.2.7 Authorization Criteria

Literature indicates that the use of HEMS has a considerable impact on the survival of severely injured patients. However, the same is not true for patients who have less severe injuries. These findings highlight the importance of the correct utilization of the pre-determined authorisation criteria to ensure appropriate use of the HEMS operation by the pre-hospital crews (Ringburg *et al.* 2009).

The authorisation criteria of the Netcare 911 HEMS operations appear to be aligned to many of the other international HEMS operations with some minor differences noted (Giannakopoulos *et al.* 2013; McQueen *et al.* 2013). The most commonly utilised Netcare 911 HEMS authorisation criteria are also directly related to the main potential benefits of HEMS operations as previously discussed:

- Life threatening medical conditions that require urgent intervention that is unavailable in the local facility (n=155, 17.5%)
- Isolated head injury where the GCS is between 5 and 12 (n=137, 15.5%)
- Where specialized equipment or expertise carried by the helicopter is required on scene (n=106, 12.0%)

Rhodes et al. (1986), concluded that if a patient is unresponsive to verbal stimuli, this clinical finding is 93% sensitive in determining a need for aeromedical transport in adult patients, whilst Moront et al. (1996) confirmed that the GCS is specific in determining which patients would benefit from HEMS transport (Rhodes, Perline and Aronson 1986; Moront, Gotschall and Eichelberger 1996).

When reviewing the appropriateness of potential authorisation criteria, it is also important to consider the potential benefits of HEMS operations. Most of the helicopter services worldwide appear to create their own authorisation criteria that tend to follow national consensus criteria. However, these criteria have the tendency to be overly broad and this may lead to abuse of the service (Bledsoe *et al.* 2006). In a country such as South Africa, which has a limited number of HEMS operations, abuse of the service may result in a situation where no helicopter is available in a case where it could definitely be of benefit to the patient (Boffard 1990).

5.3 Time Frames

There can be no doubt that a helicopter is the most effective service to utilise for patients who have time-sensitive diseases and who are situated in remote areas some distance away from definitive care as the speed of the operation allows for optimal patient outcome. In such cases, the use of helicopters has many benefits: it not only reduces the time to reach the patient, thus initiating critical patient care more speedily, but it also reduces the time to transport the patient to the most appropriate hospital for further care whilst administering a high level of care in transit. A helicopter must shorten the time to delivery of care (whether on-scene by skilled aeromedical crew or in-hospital) in order to provide any form of benefit to the patient (Floccare *et al.* 2013).

A number of international studies exist which compared time frames of HEMS transportation with time frames of GEMS transportation, as well as the impact aeromedical crew configuration has on these time frames and most studies indicated that, in general, HEMS do not really offer a time advantage when compared to GEMS (Van Hoving, Smith and Wallis 2008; Butler, Anwar and Willett 2010). This study, however, only focused on HEMS transportations and the HEMS crew configuration and no focus was placed on GEMS. Both of the Netcare 911 HEMS operations were staffed by a medical doctor and an advanced life support paramedic.

The time to scene of the HEMS operations was not compared to GEMS as part of this study. There is however a possibility for a potential delay in the activation process of the Netcare 911 HEMS operation. The Netcare 911 HEMS operations will only respond to an incident after a set authorization process. Firstly, only registered medical personnel may request the helicopter to transport patients. This may either be the GEMS crew which attended to the patient initially in a primary transfer or the in-hospital medical personnel in the case of an inter-facility transfer. Once this request has been received by the flight desk in the dispatch centre of Netcare 911, authorization needs to be obtained based on the pre-set Netcare 911 HEMS authorization criteria either from the medical aid, RAF or provincial government. Only once authorization has been received, may the Netcare 911 HEMS operation activate and respond to the incident. Another variable which may impact on the flying time to scene is the location of the incidents in relation to the actual HEMS operation. The flying time to scene in KwaZulu-Natal was longer than the flying time to scene in Gauteng.

When comparing the mean on-scene times of both of the Netcare 911 HEMS operations with other similarly staffed operations, the mean on-scene time for the Netcare 911 HEMS operations were most often shorter in time (Ringburg *et al.* 2007; Butler, Anwar and Willett 2010; D'Andrea, Van Hoving and Smith 2014). An interesting finding was the similarity between the inter-facility transfer and primary transfer on-scene times. The expectation would be that the on-scene time for primary transfers would be reasonably longer than the on-scene time for inter-facility transfers as there may have been no advanced stabilisation prior to the arrival of the aeromedical crew. Hawkins et al. (2001) considered whether the activities of the ground crews could potentially have an impact on the scene and transport times of HEMS missions. The ground crews were frequently unable to perform basic and advanced medical procedures which were indicated due to clinical scope limitations. If these omissions could be reduced, it could have a significant impact on HEMS mission times as it would reduce the on-scene time as less clinical procedures would be required to be performed by the HEMS crew (Hawkins *et al.* 2001).

Many studies found that the on-scene times were prolonged on incidents when a medical doctor formed part of the HEMS crew. Van Hoving et al (2008) determined that, in general, HEMS crews spend too much time on scene with the patient as this prolonged scene time defies the main advantage of HEMS, which is to limit the delay to definitive care (Van Hoving, Smith and Wallis 2008). However, the reasons for the prolonged on-scene times may be due to the additional procedures performed by the medical doctors on scene when comparing the different scopes of practice (Ringburg *et al.* 2007; Butler, Anwar and Willett 2010). Studies have noted a lower mortality rate even though the on-scene times may be longer, which indicates that the advanced level of care provided by the aeromedical crew potentially negates the impact of the prolonged on-scene times (Ringburg *et al.* 2007; Hassani *et al.* 2012).

Although the transfer times from scene to hospital for both of the Netcare 911 HEMS operations were similar to another South African study which also looked at times of HEMS transfers (D'Andrea, Van Hoving and Smith 2014), comparing HEMS transfer times to GEMS transfer times was not an objective of this study. However, HEMS transfer times that are longer than GEMS transfer times can easily be justified as the HEMS operation may elect to bypass some of the district hospitals and community clinics in an attempt to source regional hospitals capable of managing potential surgical emergencies as part of definitive care while GEMS operations tend to transport patients to the nearest facility (Hardcastle 2011). Prompt transport of trauma patients to an appropriate facility for definitive care is a key component in managing these patients and delays can lead to mortality (Brown and Gestring 2013).

5.4 Aeromedical Crew Qualifications

The Gauteng and KwaZulu-Natal HEMS operations were crewed with a doctor and an ALS paramedic for all of the cases included in this study. The doctor and ALS paramedic were required to meet specific criteria in order to remain part of the active HEMS crew (Netcare 911 2013).

The staffing of HEMS operations remains a controversial topic as all of the HEMS operations across the world are staffed differently and the scopes of practice also vary between the different countries. A number of studies have attempted to address the ideal HEMS crew by comparing a doctor based HEMS operation with an ALS paramedic GEMS operation. These studies have several limitations due to the method of transport and the standard of the receiving hospital. In order to assess the ideal HEMS crew effectively, a study would have to be undertaken comparing a HEMS operation against a GEMS operation with and without a doctor (Butler, Anwar and Willett 2010).

When selecting the ideal crew for a HEMS operation, it is important to remember that one of the advantages of HEMS is the ability to bring life-saving medical care to patients at a faster rate than they would be able to reach a hospital (Floccare *et al.* 2013). The scope of practice of the paramedics utilized to crew HEMS operations has grown extensively over the years, which has raised further questions around the possible benefits of a doctor based HEMS crew over a non-doctor based crew. The benefits could vary from country to country though, depending on the regional system and scope of practice of the paramedics as well as the comfort of the doctors in the pre-hospital environment (Brown and Gestring 2013).

The focus should not only be on scope though, as a medical doctor may contribute to patient care and stabilisation by bringing a higher level of clinical judgement and decision making (Snooks *et al.* 1996; Butler, Anwar and Willett 2010). Galvagno et al (2012) performed a literature search from 1966 to December 2002, searching for all papers that focused on the use of doctors in HEMS operations. In total, 126 papers were produced by the search criteria, although only 12 were relevant. The majority of relevant studies found that the inclusion of a doctor as part of the HEMS crew was beneficial as it resulted in a lower mortality. This drop in mortality was attributed to the clinical decision making of the doctors rather than the advanced scope (Galvagno *et al.* 2012).

The staffing of the Netcare 911 HEMS operation has recently undergone a change. With the inclusion of Rapid Sequence Intubation (RSI) into the Emergency Care Practitioner's (ECP) scope of practice, it is now standard for the Netcare 911 helicopter to be crewed with an ECP and an ALS paramedic (NDip or CCA). On the odd occasion when a doctor is available, the helicopter is crewed with a doctor and then either an ECP or ALS paramedic makes up the second medical crew (Netcare 911 2013). This crew still needs to comply with the set criteria as per Netcare 911 to retain their active flight status. These criteria ensure that the ECP and ALS paramedic crew have had a high level of exposure to severely ill or injured patients and are therefore more experienced at managing these types of patients. The aeromedical crew must be able to meet the clinical needs of the patients transported.

5.5 Clinical Procedures Performed

The patients transported by the Netcare 911 HEMS operations had a number of clinical procedures performed and medications administered by the GEMS and HEMS medical personnel. As previously indicated, both of the HEMS operations were crewed with a medical doctor and ALS paramedic for the duration of this study. Taking this into consideration, all of the procedures performed by the GEMS and HEMS medical personnel fell within the aeromedical crew's scope of practice. If one had to consider the recent changes to the staffing structure of the Netcare 911 HEMS operation, the aeromedical crew would still have been able to perform most of the clinical procedures. When reviewing the ECP scope of practice, the majority of the clinical procedures and medications utilized fell within the ECP scope of practice. Intercostal drains (n=6, 1.1%) and central venous access (n=15, 2.5%) were the only clinical procedures performed on patients transported that did not form part of the ECP scope of practice. The medications that were utilized on a routine basis, such as Morphine, Midazolam, Suxamethonium Chloride, Etomidate and Vecuronium Bromide, all form part of the ECP scope.

A number of international studies have highlighted advanced airway management as a key clinical procedure for HEMS aeromedical crew (Butler, Anwar and Willett 2010; Mommsen *et al.* 2012; Taylor *et al.* 2012). This is supported by the results of this study as the most commonly performed airway clinical procedure was oral endotracheal intubation. Whilst reviewing the medications utilized by the aeromedical crew, it is also clear that the medications utilized to assist with the intubation process form part of the RSI process.

The study found that patients with isolated head injuries were frequently attended to by both of the Netcare 911 HEMS operations. Patients with severe head injuries were noted to have a 9% mortality reduction when transported by HEMS (Davis *et al.* 2005). This is probably attributed to the advanced airway management and clinical procedures performed by the aeromedical crew which is inclusive of RSI. It is essential to maintain adequate cerebral perfusion pressure in patients that have sustained a head injury with potentially elevated intracranial pressure to prevent secondary brain injury. Certain medications such as Etomidate and Ketamine lessen the possibility of major variations in cerebral perfusion pressure (Reich *et al.* 2005). A study by Wang et al. (2004), found that although patients with severe head injuries who had been intubated in the pre-hospital environment had worse outcomes and survival, this did not apply to aeromedical crew as severe head injury patients intubated by HEMS crews had improved outcomes (Wang *et al.* 2004; Davis *et al.* 2005).

It is important to have an understanding of the type of clinical procedures that are likely to be required prior to and during the transfer of the patient to ensure that the aeromedical crew dispatched is suitably qualified.

5.6 Patient Outcome

The benefits of air transportation are usually related to the speed of transport as well as the specialised skills of the HEMS crew (McLaughlin 2002). Other benefits of utilizing HEMS operations are that they can retrieve patients from remote locations and they are then able to remove the patient to a specialist centre (Butler, Anwar and Willett 2010). All of the aforementioned benefits are of little value if there is no improvement in patient outcome as the helicopter is a costly resource. It is therefore essential that a HEMS operation should only be utilised for patients who are likely to receive maximal benefit from this form of transport (Cudnik *et al.* 2012).

Over the years there have been a number of studies attempting to analyse the association of trauma mortality and the use of HEMS operations to transport trauma patients. Despite all of these studies, this topic still remains an area for debate as the settings, aeromedical crew qualifications, patients and methodologies vary from study to study (Stewart *et al.* 2011). The general finding is that patients transported by HEMS operations are associated with improved outcomes (Moylan 1988; Cudnik *et al.* 2012; Giannakopoulos *et al.* 2013). This is specifically true for time sensitive diagnoses. Patients with traumatic brain injuries and those suffering from polytrauma need to arrive at a Level one trauma centre within the Golden Hour to avoid any possible delays for surgical interventions. Patients having a myocardial infarction or stroke require rapid transportation to a facility that has catheterization facilities and thrombolytic therapy (Mommsen *et al.* 2012). The Netcare 911 HEMS operations most commonly transported patients that fell within these time sensitive diagnoses: motor vehicle accident (n=193, 36.9%), pedestrian vehicle accident (n=69, 12.9%) and cardiac (n=37, 6.9%).

Even though the evidence indicates that HEMS operations can lead to improved patient outcomes in trauma patients, it would appear that the HEMS operations are over utilized. Adult patients have an over-triage rate of 60% and paediatric patients have an over-triage rate of 85% in trauma incidents. A meta-analysis of 22 studies determined that one in four HEMS transported patients were discharged within 24 hours of arrival at a trauma centre and up to 70% had non-life threatening injuries (Bledsoe et al. 2006; Cudnik et al. 2012). Analysing the results from the Netcare 911 HEMS operations, it may be possible that there was a potential for over-triage as at the 24 hour follow up point, 339 (63.1%) patients were alive and stable and 10 (1.9%) had already been discharged. These findings were statistically significant as the p value was < 0.05. At the 72 hour follow up, 404 (75.3%) were alive and stable and 37 (6.9%) had been discharged.

A number of studies also reflect that patients with an ISS > 15 require a higher level of specialized care and this is supported by the finding that HEMS transportation results in a reduction in mortality in these patients (Nicholl, Brazier and Snooks 1995; Galvagno *et al.* 2012). In a study conducted by Cudnik et al (2012), up to 72% of patients had minor injuries with an ISS ≤ 15, suggesting that HEMS operations were being over-utilized (Cudnik *et al.* 2012). Analysing the patient outcome statistics of this study, this finding may also be true and correct for the patients transported by the Netcare 911 HEMS operations.

Although there are some perceived benefits of HEMS operations, the annual costs are very high and in one study it ranged from $115 777 to $5 571 578 per annum (Taylor *et al.* 2010). In the South African context, the cost of operating a twin engine aeromedical helicopter would cost approximately R30 000 per flying hour. Due to these significant cost implications, it is crucial that patients are airlifted from locations that would result in some form of benefit to the patient.

5.7 Limitations of the study

The limitations of this study were:

1. The study was limited to patients transported by the Netcare 911 HEMS operations in Gauteng and KwaZulu-Natal. The other private and provincial HEMS operations across South Africa were not included.
2. As the data collection process was retrospective in nature and existing EPFR documentation was utilized to extract patient information, in some instances the researcher was unable to clearly differentiate between clinical procedures performed and medications administered by the GEMS and HEMS medical personnel.
3. The third limitation was that the EPRF and follow up documentation did not make provision for the actual injuries found during the aeromedical transfer and/or in-hospital admission process.
4. The cost implications of utilizing a HEMS operation to transport patients instead of a GEMS operation were not a focus area of this study.

5.8 Conclusion

This chapter provided a comprehensive interpretation and discussion of the results for each of the objectives of the study. The following chapter contains conclusions as well as the recommendations of this study.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

A HEMS operation is a flying emergency department where on-board medical personnel have both the knowledge and equipment to perform complicated medical procedures and assist in the transfer of ill and/or injured patients to the most appropriate facility. As the HEMS is a very costly resource, it is essential that the resource is utilized in situations that would offer the most benefit to the patient. Although a number of international studies have been conducted describing the types of patients flown, the time frames associated with HEMS transfers, the aeromedical crew and patient outcome, only two local studies were identified. This descriptive, retrospective study aimed to provide an analysis of the patients flown by the Netcare 911 HEMS operations in Gauteng and KwaZulu-Natal over a 12 month period. In the 12 month study period there were a total of 547 cases. However, the final study population was made up of 537 cases as 10 cases had to be excluded due to incomplete documentation. Of the 537 cases, 82 (15.3%) were managed by the KwaZulu-Natal HEMS and 455 (84.7%) were managed by the Gauteng HEMS. Findings revealed that the majority of patients flown in both Gauteng and KwaZulu-Natal were adult males: males (n=398; 74.1%) and adults (n=437; 81.4%). Motor vehicle accidents were the most common incident type for both operations (n=193; 36%). At the 24-hour follow up, 339 (63.1%) patients were alive and stable and at the 72-hour follow up, 404 (75.3%) were alive and stable. While a number of findings were in line with several of the international and local studies, certain results were concerning. These results will be discussed in further detail in this chapter.

6.2 Recommendations

6.2.1 Location of HEMS operation in relation to incidents

This study has shown that both of the Netcare 911 HEMS operations were routinely dispatched to urban areas which were in close proximity to Level one facilities. Both of the HEMS operations were also located in urban districts, as the Gauteng HEMS operation is based in Midrand, which falls within the City of Johannesburg Metropolitan Municipality and the KwaZulu-Natal HEMS operation was based in Durban North, which forms part of the eThekwini Metropolitan Municipality.

Although there is some perceived benefit in having a HEMS operation in an urban environment as there may be delays due to traffic congestion, the greatest benefit has been identified in the rural environment. A HEMS operation is most valuable in rural areas where access to doctors and medical expertise is not routinely available and the distance to an appropriate hospital would result in significant time delays.

The researcher recommends that the HEMS operations are positioned in rural areas where there is a definite need as well as proven benefit to patients. This rural placement would ensure that the patients in these rural areas have prompt access to medical expertise so that advanced life support interventions can be initiated early on and there is a continuum of high level care for critically ill or injured patients as they are transported over a fair distance to an appropriate Level one facility. If the actual placement of the HEMS operation within a rural environment is not a feasible option, then the focus of the HEMS operation should be on retrieving critically ill or injured patients that meet the appropriate authorisation criteria from the rural areas instead of the urban environment.

6.2.2 Authorisation Criteria

The current authorisation criteria are overly broad and have the potential to lead to abuse by the GEMS operations requesting assistance from HEMS. The authorisation criteria for the HEMS operation need to be closely related to the potential benefits of HEMS. These include: 1) potential shorter transport times; 2) the helicopter being able to transport the patient directly to a specialized medical facility; 3) the aeromedical crew being able to provide a higher level of care than the GEMS in terms of medical equipment and expertise; and 4) the helicopter being able to access environments which cannot be accessed by GEMS.

It is essential that the incident types attended to by the HEMS operation are likely to benefit from this costly resource. Taking the potential benefit of speed into account, the patients transported should have time sensitive pathologies such as traumatic haemorrhage, ST-elevation myocardial infarction, polytrauma, traumatic brain injury, burns, stroke and paediatric emergencies. These patients may potentially benefit from the shorter transport times and it is also imperative that these time sensitive pathologies are transported to a facility that can provide the appropriate level of care required. The distance from hospital and specific logistical considerations should also be considered, as this has the potential to delay treatment.

The qualification and scope of the aeromedical crew is also an important factor to consider when dispatching the HEMS operation. If the qualifications and scope of the HEMS crew are the same as the GEMS crew, then there is no potential benefit in terms of the medical expertise of the crew. In this event, the HEMS would only act as a “faster” mode of transport. The time benefit is not a given as the time saved is dependent on a number of variables.

There are also potential ethical considerations relating to the cost of the HEMS operation. The cost of this expensive resource must be justifiable which may be determined by scientifically validated authorization criteria.

The researcher recommends that the authorization criteria are reviewed to ensure that they are aligned to the possible benefits of HEMS operations.

6.2.3 Time Frames

A HEMS operation must form an adjunct to, and not a substitute for a GEMS operation. At present, there is a delayed activation of HEMS operations as the helicopter is only dispatched on request by a GEMS crew for primary transfers or in-hospital medical personnel for an inter-facility transfer. This leads to prolonged pre-hospital times for the patient, delaying definitive care at an appropriate facility. In this study, the flying time to scene in KwaZulu-Natal was longer than the flying time to scene in Gauteng. The reasons for this were due to the location of the HEMS operation in KwaZulu-Natal in relation to the incident locations. Once again, careful consideration of the positioning of the HEMS operation as well as a review of the authorization process may reduce the flying time to scene. Both of the helicopters were based in urban areas, and the flying time to scene may potentially be reduced by placing the helicopters in the more rural areas.

The qualification and scope of the aeromedical crew has the potential to impact the on-scene times. A number of studies identified that having a medical doctor as part of the aeromedical crew prolonged on-scene times. However, this delay was justifiable as the patient was receiving a high level of care equivalent to that of an emergency department. A helicopter must shorten the time to definitive care whether this care is started on scene by the highly skilled aeromedical crew or in-hospital.

The researcher recommends that the time frames of the cases attended to are closely monitored to determine where the possible delays may be, and that measures are put in place to limit these delays. This may involve adapting the way in which calls are authorized as well as changing the physical location of the HEMS operations to rural sites.

6.2.4 Qualification of the Aeromedical Crew

One of the benefits of a HEMS operation is to bring life-saving medical care to patients at a faster rate than they would be able to reach a hospital. This essentially means bringing the emergency department to the patient, instead of the patient to the emergency department. It is therefore imperative that the helicopter is staffed with highly skilled crew.

At the time of this study, the Netcare 911 HEMS operation was crewed by a medical doctor and an ALS paramedic. More recently, the crew has been changed to consist of an ECP and an ALS paramedic. Although the majority of the clinical procedures and medications fell within the ECP scope of practice, the researcher is of the opinion that the aeromedical crew should still be made up of a medical doctor and an ECP or ALS paramedic. The focus should not only be on the scope of practice of the ECP, but the high level of clinical judgement and decision making which a medical doctor may add to the aeromedical crew. As mentioned, a HEMS operation is a costly resource and needs to be utilized correctly to maximise its benefits. One of the benefits of a HEMS operation is that the aeromedical crew can provide a higher level of care when compared to GEMS in terms of medical equipment and expertise. This may not be true if there is no medical doctor on board the HEMS operation.

6.2.5 Patient outcome

Findings from other studies have shown that patients with a time sensitive diagnoses and an ISS > 15 benefit the most from HEMS transportation.

In this study, the majority of the patients were over-triaged as the majority were alive and stable or discharged within 24 and 72 hours. The analysis also revealed that a fairly high number of patients were deceased at 24 and

72 hours, suggesting that their condition had been so critical that they had little chance of survival. The utilization of the HEMS cannot be justified in such cases.

The researcher recommends that the authorization criteria are refined to identify those specific patients that would benefit the most from HEMS transportation.

6.3 Recommendations for Further Research

Further studies are required to clearly identify the specific type of patients that would benefit the most by being transported to hospital by the HEMS operations. This would then allow for the revision of the current authorization criteria. This study should be prospective in nature to allow for additional information to be included as part of the data collection process, such as injury type. The outcome of specific injury types may add value to the authorization criteria requirements.

Another study should also be conducted within the Netcare 911 HEMS operation, analysing the impact the change in the composition of the aeromedical crew has had on the HEMS operation, with specific reference to the time frames, clinical procedures and patient outcomes.

Similar studies should also be undertaken within the public HEMS sector.

8. REFERENCES

Air ambulance Victoria. 2013. Available: http://www.ambulance.vic.gov.au (Accessed August 2011).

AMS. 2011. *Red cross air mercy service*. Available: http://www.ams.org.za (Accessed September 2013).

Ashcroft, R., Dawson, A., Draper, H. and McMillan, J. 2007. *Principles of health care ethics*. 2nd ed. John Wiley & Sons, Ltd.

Babbie, E. R. 2010. *The practice of social research*. Available: http://www.libguides.usc.edu (Accessed September 2013).

Bledsoe, B. E. 2003. *EMS myth # 6: air medical helicopters save lives and are cost effective*. Available: http://www.emsworld.com (Accessed September 2011).

Bledsoe, B. E., Wesley, A. K., Eckstein, M., Dunn, T. M. and O'Keefe, M. F. 2006. Helicopter scene transport of trauma patients with nonlife-threatening injuries: a meta-analysis. *The journal of trauma*, 60 (6): 1257-1265.

Boffard, K. D. 1990. Patient transport by air. *The journal of accident and emergency medicine*, May/June: 119-121.

Brown, J. B. and Gestring, M. L. 2013. Does helicopter transport impact outcome following trauma? *Trauma*, 15 (4): 279-288.

Brown, J. B., Stassen, N. A., Bankey, P. E., Sangosanya, A. T., Cheng, J. D. and Gestring, M. L. 2010. Helicopters and the civilian trauma system: national utilization patterns demonstrate improved outcomes after traumatic injury. *Journal of trauma, injury, infection & critical care*, 69 (5): 1030-1036.

Brown, J. B., Stassen, N. A., Bankey, P. E., Sangosanya, A. T., Cheng, J. D. and Gestring, M. L. 2011. Helicopters improve survival in seriously injured patients requiring interfacility transfer for definitive care. *Journal of trauma, injury, infection & critical care*, 70 (2): 310-314.

Burillo-Putze, G., Duarte, I. H. and Alvarez Fernandez, J. A. 2001. Helicopter emergency medical services in Spain. *Air medical journal*, 20 (3): 21-23.

Butler, D. P., Anwar, I. and Willett, K. 2010. Is it the H or the EMS in HEMS that has an impact on trauma patient mortality? A systematic review of the evidence. *Emergency medicine journal*, 27 (9): 692-701.

Callahan, T. C. and Hobbs, R. 1998. *Ethics in medicine*. Available: http://depts.washington.edu/bioethx (Accessed January 2012).

Careless, J. 2010. *Helicopter EMS: part 1: a brief history*. Available: http://www.emsworld.com (Accessed September 2011).

Chappel, V. L., Mileski, W. J., Wolf, S. E. and Gore, D. C. 2002. Impact of discontinuing a hospital-based air ambulance service on trauma patient outcomes. *The journal of trauma*, 52: 486-491.

Civil aviation authority 2013. Available: http://www.caa.co.za/ (Accessed November 2013).

Cohen, L., Manion, L. and Morison, K. 2000. *Research methods in education*. 5th ed. Routledge Falmer.

Creswell, J. W. 2009. *Research design: qualitative, quantitative and mixed methods approaches*. Third ed. Sage.

Creswell, J. W., Ebersohn, L., Eloff, I., Ferreira, R., Ivankova, N. V., Jansen, J. D., Nieuwenhius, J., Pietersen, J., Plano Clark, V. L. and van der Westhuizen, C. 2007. *First steps in research*. Van Schaik.

Cudnik, M. T., Werman, H. A., White, L. J. and Opalek, J. M. 2012. Prehospital factors associated with mortality in injured air medical patients. *Prehospital emergency care*, 16 (1): 121-127.

Cunningham, P., Rutledge, R., Baker, C. C. and Clancy, T. V. 1997. A comparison of the association of helicopter and ground ambulance transport with the outcome of injury in trauma patients transported from the scene. *Journal of trauma, injury, infection & critical care*, 43 (6): 940-946.

D'Andrea, P. A., Van Hoving, D. J. and Smith, W. P. 2014. A 5-year analysis of the helicopter air mercy service in Richards Bay, South Africa. *South African Medical Journal*, 104 (2): 124-126.

Davis, D. P., Peay, J., Serrano, J. A., Buono, C., Vilke, G. M., Sise, M. J., Kennedy, F., Eastman, A. B., Velky, T. and Hoyt, D. B. 2005. The impact of aeromedical response to patients with moderate to severe traumatic brain injury. *Annals of emergency medicine*, 46 (2): 115-122.

Diaz, M. A., Hendey, G. W. and Bivins, H. G. 2005. When is a helicopter faster? A comparison of helicopter and ground ambulance transport times. *Journal of trauma, injury, infection & critical care*, 58 (1): 148-153.

ER24. 2013. *ER24 - emergency medical care and response services*. Available: http://www.er24.co.za (Accessed September 2013).

Ethics at a glance. 2013. Available: http://rhchp.regis.edu/HCE/EthicsAtAGlance/Nonmaleficence/Nonmaleficence.pdf (Accessed November 2013).

Farlex. 2013. *Air ambulance definition*. Available: http://www.thefreedictionary.com (Accessed September 2011).

Floccare, D. J., Stuhlmiller, D. F. E., Braithwaite, S. A., Thomas, S. H., Madden, J. F., Hankins, D. G., Dhindsa, H. and Millin, M. G. 2013. Appropriate and safe utilization of helicopter emergency medical services: a joint position statement with resource document. *Prehospital emergency care*, 17 (4): 521-525.

Frankema, S. P., Ringburg, A. N., Steyerberg, E. W., Edwards, M. J., Schipper, I. B. and van Vugt, A. B. 2004. Beneficial effect of helicopter emergency medical services on survival of severely injured patients. *The British journal of surgery*, 91 (11): 1520-1526.

Galvagno, S. M., Haut, E. R., Nabeel Zafar, S., Millin, M. G., Efron, D. T., Koenig, G. J., Baker, S. P., Bowman, S. M., Pronovost, P. J. and Haider, A. H. 2012. Association between helicopter vs ground emergency medical services and survival for adults with major trauma. *The journal of the american medical association*, 307 (15): 1602-1610.

Giannakopoulos, G. F., Kolodzinskyi, M. N., Christiaans, H. M. T., Boer, C., de Lange-de Klerk, E. S. M., Zuidema, W. P., Bloemers, F. W. and Bakker, F. C. 2013. Helicopter emergency medical services save lives: outcome in a cohort of 1073 polytrauma patients. *European journal of emergency medicine*, 20 (2): 79-85.

Gillon, R. 1994. Medical ethics: four principles plus attention to scope. *BMJ*, (309): 184.

Hardcastle, T. 2011. The 11 P's of an Afrocentric trauma system for South Africa - time for action! *South African Medical Journal*, 101 (3): 160-161.

Hassani, S. A., Moharari, R. S., Sarvar, M., Nejati, A. and Khashayar, P. 2012. Helicopter emergency medical service inTehran, Iran: a descriptive study. *Air medical journal*, 31 (6): 294-297.

Hawkins, S. C., Morgan, S., Waller, A., Winslow, T. and McCoy, M. 2001. Effects of ground EMS and ED personnel on air medical trauma on-site times. *Air medical journal*, 20 (3): 32-36.

Health Professions Council of South Africa. 2013. Available: http://www.hpcsa.co.za/ (Accessed October 2013).

Helivac. 2011. *Helivac*. Available: http://www.helivac.co.za (Accessed August 2011).

Holleran, R. S. 2003. *Air and surface patient transport: principles and practice*. Mosby.

Hotvedt, R., Kristiansen, I. S., Forde, O. H., Thoner, J., Almdahl, S. M., Bjorsvik, G., Berge, L., Magnus, A. C., Mamen, K., Sparr, T. and Ytre-Arne, K. 1996. Which groups of patients benefit from helicopter evacuation? *The lancet*, 347 (9012): 1362-1366.

Johnson, B. and Dimopoulos, G. E. 1998. An analysis of aeromedical transportation of patients in KwaZulu Natal. *Trauma and emergency medicine*, August/September: 6-8.

Kotch, S. J. and Burgess, B. E. 2002. Helicopter transport of pediatric versus adult trauma patients. *Prehospital emergency care*, 6 (3): 306-308.

London's air ambulance. 2013. Available: http://www.londonsairambulance.co.uk (Accessed August 2011).

Martikainen, M. 2000. Helicopter emergency medical services in Finland. *Air medical journal*, 19 (4): 148.

Martin, T. 2006. *Aeromedical transportation: a clinical guide*. Second ed. Ashgate.

McDonald, J. H. 2014. *Handbook of Biological Statistics*. 3rd ed. Sparky House Publishing.

McLaughlin, M. 2002. To fly or not to fly? *Air medical journal*, 21 (4): 26-27.

McQueen, C., Crombie, N., Perkins, G. D. and Wheaton, S. 2013. Impact of introducing a major trauma network on a regional helicopter emergency medicine service in the UK. *Emergency medicine journal*, 30 (7): 1-7.

Melton, J. T., Jain, S., Kendrick, B. and Deo, S. D. 2007. Helicopter emergency ambulance service (HEAS) transfer: an analysis of trauma patient case-mix, injury severity and outcome. *Annals of the royal college of surgeons of England*, 89 (5): 513-516.

Mercy flight western New York. 2013. Available: http://www.mercyflight.org (Accessed August 2011).

Mommsen, P., Bradt, N., Zeckey, C., Andruszkow, H., Petri, M., Frink, M., Hildebrand, F., Krettek, C. and Probst, C. 2012. Comparison of helicopter and ground emergency medical service: a retrospective analysis of a German rescue helicopter base. *Technology and health care*, 20 (1): 49-56.

Moront, M. L., Gotschall, C. S. and Eichelberger, M. R. 1996. Helicopter transport of injured children: system effectiveness and triage criteria. *Journal of paediatric surgery*, 31: 1183-1186.

Moylan, J. A. 1988. Impact of helicopters on trauma care and clinical results. *Annals of surgery*, 208 (6): 673-678.

Myhre, J. A. 1988. Impact of helicopters on trauma care and clinical results. *Annals of surgery*, 208 (6): 673-678.

Netcare 911. 2013 *Netcare 911*. Available: http://netcare911.co.za (Accessed September 2013).

Nicholl, J. P., Brazier, J. E. and Snooks, H. A. 1995. Effects of London helicopter emergency medical service on survival after trauma. *British medical journal*, 311 (6999): 217-222.

Phelan, C. and Wren, J. 2005. *Exploring reliability in academic assessment*. Available: https://www.uni.edu/chfasoa/reliabilityandvalidity.htm (Accessed March 2015).

Pollak, A. N., Murphy, M., Stathers, C. L., Pecora, D., McEvoy, M. and Rabricj, J. S. 2011. *Critical care transport*. Jones and Bartlett.

Reich, D. L., Hossain, S., Krol, M., Baez, B., Patel, P., Bernstein, A. and Bodian, C. A. 2005. Predictors of hypotension after induction of general anesthesia *Anesthesia & Analgesia*, 101 (3): 622.

Rhodes, M., Perline, R. and Aronson, J. 1986. Field triage for on-scene helicopter transport. *Journal of trauma*, 26: 963-969.

Ringburg, A. N., Spanjersberg, W. R., Frankema, S. P. G., Steyerberg, E. W., Patka, P. and Schipper, I. B. 2007. Helicopter emergency medical services (HEMS): impact on scene times. *Journal of trauma, injury, infection & critical care*, 63 (2): 258-262.

Ringburg, A. N., Thomas, S. H., Steyerberg, E. W., van Lieshout, E. M., Patka, P. and Schipper, I. B. 2009. Lives saved by helicopter emergency medical services: an overview of literature. *Air medical journal*, 28 (6): 298-302.

Road accident fund 2011. Available: http://www.raf.co.za/about-us/pages/profile.aspx (Accessed September 2014).

Schwartz, R. J., Jacobs, L. M. and Yaezel, D. 1989. Impact of pre-trauma center care on length of stay and hospital charges. *Journal of trauma*, 29: 1611-1615.

Shepherd, M. V., Trethewy, C. E., Kennedy, J. and Davis, L. 2008. Helicopter use in rural trauma. *Emergency medicine Australasia*, 20 (6): 494-499.

Snooks, H. A., Nicholl, J. P., Brazier, J. E. and Lees-Mlanga, S. 1996. The costs and benefits of helicopter emergency ambulance services in England and Wales. *Journal of public health medicine*, 18 (1): 67-77.

STAR. 2006. *Specialized trauma air response*. Available: http://www.isisa.co.za/isisa/star/default.htm (Accessed August 2011).

Stewart, K. E., Cowan, L. D., Thompson, D. M., Sacra, J. C. and Albrecht, R. 2011. Association of direct helicopter versus ground transport and in-hospital mortality in trauma patients: a propensity score analysis. *Academic emergency medicine*, 18: 1208-1216.

Stratton, S. J. 2013. Should helicopters dispatched for EMS trauma response be grounded? *Annals of emergency medicine*, 62 (4): 365-366.

Sullivent, E. E., Faul, M. and Wald, M. M. 2011. Reduced mortality in injured adults transported by helicopter emergency medical services. *Prehospital emergency care*, 15 (3): 295-302.

Svenson, J. E., O'Connor, J. E. and Lindsay, M. B. 2006. Is air transport faster? A comparison of air versus ground transport times for interfacility transfers in a regional referral system. *Air medical journal*, 25 (4): 170-172.

Taylor, C., Jan, S., Curtis, K., Tzannes, A., Li, Q., Palmer, C., Dickson, C. and Myburgh, J. 2012. The cost-effectiveness of physician staffed helicopter emergency medical service (HEMS) transport to a major trauma centre in NSW, Australia. *Injury, international journal of the care of the injured*, 43 (11): 1843-1849.

Taylor, C. B., Stevenson, M., Jan, S., Middleton, P. M., Fitzharris, M. and Myburgh, J. A. 2010. A systematic review of the costs and benefits of helicopter emergency medical services. *Injury, international journal of the care of the injured*, 41: 10-20.

Van Hoving, D. J., Smith, W. P. and Wallis, L. A. 2008. Comparison of mean on-scene times: road versus air transportation of critically ill patients in the Western Cape of South Africa. *Emergency medicine journal*, 25: 136-139.

Wang, H. E., Peitzman, A. B., Cassidy, L. D., Adelson, P. D. and M, Y. D. 2004. Out-of-hospital endotracheal intubation and outcome after traumatic brain injury. *Annals of emergency medicine*, 44 (5): 439-450.

Wikipedia. 2013a. *Air Ambulance*. Available: http://en.wikipedia.org/wiki/Air_ambulance (Accessed September 2011).

Wikipedia. 2013b. *Districts of South Africa*. Available: http://www.wikipedia.org/wiki/districts_of_South_Africa (Accessed September 2013).

Wikipedia. 2013c. *Sikorsky R-4*. Available: http://en.wikipedia.org/wiki/Sikorsky_R-4 (Accessed November 2013).

Williams, C. 2007. Research methods. *Journal of business & economic research*, 5 (3): 65-72.

Workers' compensation in the Republic of South Africa 2008.

Appendix 1: Ethical clearance from the Institution Research Ethics Committee (IREC) DUT

DURBAN UNIVERSITY *of* TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

20 August 2012

IREC Reference Number: **REC 36/12**

Mrs D Muhlbauer
P O Box 45
Caledon
Zimbali
4418

Dear Mrs Muhlbauer

An analysis of patients transported by a Private Helicopter Emergency Service within South Africa

I am pleased to inform you that Full Approval has been granted to your proposal REC 36/12.

The Proposal has been allocated the following Ethical Clearance number **IREC 029/12**. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely

[redacted]

Dr D F Naude
Chairperson: IREC

Appendix 2: Permission letter from Netcare 911 Research Committee

23 April 2012

Netcare 911 Research Committee Chairperson
Netcare 911 Head Office
Riverview Office Park
Janadel Road
Midrand
1685

Dear Mr.N. Nevin

Request for approval to undertake research

I am currently registered at the Durban University of Technology with the Department of Emergency Care and Rescue with the aim of completing a Masters Degree: Emergency Medical Care. I wish to undertake my research project within the Netcare 911 HEMS operation.

Student name:	Dagmar Muhlbauer (Student number: 21143532)
Supervisor:	Mr Raveen Naidoo (0836519595)
Co-Supervisor:	Dr.Timothy Craig Hardcastle (0824681615)

Title of Research:
An Analysis of patients transported by a Private Helicopter Emergency Medical Service within South Africa

Aim of Research:
The aim of this study is to undertake a descriptive analysis of the patients flown by the Netcare 911 Helicopter Emergency Medical Service over a 12 month period both in Gauteng and KwaZulu-Natal and to assess the patient's outcome.

Objectives of Research:
1. To analyse the clinical demographics of the patients transported by the Netcare 911 HEMS operations.
2. To assess time frames from dispatch of the helicopter to delivery of the patient to the receiving hospital facility.
3. To document the specific clinical procedures performed on the patient transported by the HEMS operation.
4. To analyse the clinical outcome of the patients transported by the HEMS operation at 24 hours and 72 hours.

Risks:
The clinical records contain patient information, however, each clinical record will be assigned a number and no identifying data will be recorded at any stage. All data will be collected and entered into an electronic spreadsheet; Microsoft Office Excel © 2007, with password protection. All data will be handled with the strictest confidentiality and only the researcher and supervisor will have access to the data.

A bound hard copy of the research proposal will be forwarded to your office once approval has been received from the faculty research committee of the Durban University of Technology.

All research findings will be made available to you. This will be done in the form of a report on completion of the project and forwarded to you on your request.

I trust this will meet your favourable consideration and approval.

Regards

[redacted]

MRS. DAGMAR MUHLBAUER
Training Manager – Netcare 911 KZN
Cell number: 082 444 3671

NETCARE 082 911
24HR EMERGENCY MEDICAL ASSISTANCE
AN AUTHORISED FINANCIAL SERVICES PROVIDER

Netcare 911
Riverview Office Park
410 Janadel Road
Midrand
1685
PO Box 3455 Halfway House
South Africa 1685
Tel +27 (0) 10 209 8911
Fax: +27 (0) 10 209 8980
E-mail: info@netcare.co.za
Web: www.netcare911.co.za

18 September 2012

Dear Dagmar Muhlbauer,

RE: Application to Netcare 911 data for Masters Studies

Your research application was reviewed by the Netcare 911 Research Committee. In lieu of the nature of your proposed study, we approve your request to have access to our data.

We wish you all the best with your research and we would request a copy of your dissertation once completed.

If you have any questions, feel free to contact me directly.

Kindest Regards.

[redacted]

Nick Nevin
Chairman: Research Committee
Netcare 911 Medical Division
Midrand

International Assistance
Tel +27 (0) 10 209 8387
Fax +27 (0) 10 209 8405
E-mail assist@netcare.co.za

Aeromedical
Tel +27 (0) 10 209 8392
Fax +27 (0) 10 209 8405
E-mail flight@netcare.co.za

NETCARE
You're in safe hands

Appendix 3: Capabilities of Advanced Life Support Paramedics

CAPABILITY	CCA/NDip	ECT	ECP
Airway Management			
Finger sweep	√	√	√
Head-tilt-chin lift	√	√	√
Jaw-thrust	√	√	√
Suctioning of the airway	√	√	√
Airway obstruction removal techniques	√	√	√
Use of Magill's forceps	√	√	√
Oropharyngeal airway insertion	√	√	√
Nasopharyngeal tube airway insertion	√	√	√
Cricoid pressure	√	√	√
Orotracheal intubation	√		√
Nasotracheal intubation	√		√
Blind nasotracheal intubation	√		√
Digital endotracheal intubation	√		√
Retrograde intubation	√		√
Supraglottic extraglottic airway devices insertion	√	√	√
Orogastric tube insertion	√	√	√
Nasogastric tube insertion	√	√	√
Needle cricothyroidotomy	√	√	√
Surgical cricothyroidotomy	√		√
Rapid sequence intubation, only with capnography & ventilator			√

Oxygenation and Ventilation			
Oxygen therapy	√	√	√
Nebulization (medicated)	√	√	√
Use of pulse oximetry	√	√	√
Needle thoracentesis	√	√	√
Bag valve mask ventilation	√	√	√
Bag valve tube ventilation	√	√	√
Mechanical ventilation	√		√
Use of PEEP	√		√
Use of capnography	√	√	√
Circulatory Management			
Blood pressure measurement	√	√	√
Peripheral intravenous cannulation - ≥ 8 year old patients only	√	√	√
Peripheral intravenous cannulation - all age categories	√	√	√
External jugular vein cannulation	√	√	√
Femoral vein cannulation	√		√
Intra-osseous insertion	√	√	√
Umbilical vein cannulation	√	√	√
Fluid administration	√	√	√
Intravenous drug administration	√	√	√
Intraosseus drug administration	√	√	√
Subcutaneous drug administration	√	√	√
Intramuscular drug administration	√	√	√
Endotracheal tube drug administration	√		√
Drug infusions and use of infusion devices	√		√
Use of syringe drivers	√		√
Use of non-invasive blood pressure monitors	√	√	√

External haemorrhage control including use of tourniquet	√	√	√
Use of pneumatic anti-shock garment - legs only	√	√	√
Use of pneumatic anti-shock garment - entire	√		√
Automated external defibrillation	√	√	√
Manual defibrillation (asynchronous)	√	√	√
Synchronised cardioversion	√		√
Vagal manoeuvres	√		√
Central line management	√		√
Transcutaneous cardiac pacing	√		√
3 Lead ECG monitoring	√	√	√
12 Lead ECG monitoring	√		√
Fibrinolysis			√
ECG Rhythm Analysis			
Normal sinus rhythm	√	√	√
Sinus bradycardia	√	√	√
Sinus tachycardia	√	√	√
Ventricular fibrillation	√	√	√
Ventricular tachycardia	√	√	√
Asystole / PEA	√	√	√
All other emergency cardiac dysrrhythmias	√		√
Obstetric Management			
Normal vaginal delivery	√	√	√
Prolapsed cord management	√	√	√
Breech delivery management (scope specific)	√	√	√
Mal presentations management (scope specific)	√	√	√
Preterm labour management (scope specific)	√	√	√
Obstructed labour management (scope specific)	√	√	√

Fundal massage	√	√	√
Bimanual compression	√		√
Tocolysis	√		√
General			
CPR (adult, child, infant & neonate)	√	√	√
Patient clinical assessment	√	√	√
Vital sign assessment	√	√	√
Finger prick and blood glucose measurement	√	√	√
Cervical spinal clearance	√	√	√
Application of cervical collar	√	√	√
Application of head blocks	√	√	√
Application of spider harness	√	√	√
Spinal immobilization using scoop stretcher & long spinal board	√	√	√
Spinal immobilization using an extrication device	√	√	√
Application of splints including the traction splint	√	√	√
Application of vacuum mattress	√	√	√
Use of stretchers	√	√	√
Urinary catheterization	√	√	√
Basic wound care and application of dressings	√	√	√
Suturing	√		√
Declaration of death:withdrawal of resuscitation efforts	√	√	√
Declaration of death: withholding resuscitation	√	√	√
Administration of medication as per current HPCSA protocol	√	√	√
General patient inter-facility transfer	√	√	√
Intensive care transfer	√		√
Neonatal transfer (non-intubated patient)	√	√	√

Neonatal intensive care transfer	√		√

Appendix 4: Medications for Administration by Advanced Life Support Paramedics

Medications	CCA/NDip	ECT	ECP
Acetyl Salicylic Acid	√	√	√
Activated charcoal	√	√	√
Adenosine	√		√
Adrenaline	√	√	√
Amiodarone	√	√	√
Atropine sulphate	√	√	√
Calcium chloride 10%	√		√
Clopidogrel	√		√
Corticosteroids – hydrocortisone / methylprednisolone	√	√	√
Cyclimorph			√
Dextrose 5%			√
Dextrose 50%	√	√	√
Diazepam	√	√	√
Enoxaparin			√
Etomidate			√
Flumazenil	√	√	√
Furosemide	√		√
Glucagon	√	√	√
Glyceryl Trinitrate	√	√	√
Heparin sodium			√
Ipratropium Bromide	√	√	√
Ketamine			√
Lignocaine hydrochloride (local)	√		√

Lignocaine hydrochloride (systemic)	√		√
Lorazepam	√		√
Magnesium sulphate	√	√	√
Medical oxygen	√	√	√
Metoclopramide monohydrochloride	√		√
Midazolam	√		√
Morphine sulphate	√	√	√
Naloxone hydrochloride	√	√	√
Nitrous oxide	√	√	√
Oral glucose powder/gel	√	√	√
Promethazine	√	√	√
Rocuronium			√
Sodium bicarbonate 8.5%	√		√
Streptokinase			√
Suxamethonium chloride			√
Tenecteplase			√
Thiamine	√	√	√
Vecuronium			√
β_2 Stimulants (inhaled)	√	√	√
β_2 Stimulants (systemic)	√		√

Appendix 5: Data collection tool

DATE	

CASE NUMBER	

HEMS OPERATION	1	KZN
	2	JHB

LOCATION / AREA	

CALL AUTHED	1	Isolated head injury where the GCS is between 5 and 12
	2	Head injury with focal neurological fallout
	3	Initial blood pressure of less than 80 mmHg systolic
	4	Where signs and symptoms indicate a spinal injury and road transportation time exceeds 20 minutes or where extreme terrain prevents safe ground transport
	5	Patients with respiratory distress despite supplemental oxygen
	6	Amputations: Above knee or elbow with significant vascular compromise
	7	Severe penetrating injury trauma to head, neck, thorax and/or abdomen with possible involvement of the underlying organs or vascular structures
	8	Near drowning with neurological deficit or haemodynamic compromise
	9	Electrocution with unstable arrhythmia or neurological deficit
	10	Hypothermia (<35 deg Celsius) or hyperthermia (>40 deg Celsius)
		Burns:
		11 In adults with 20-80% BSA

		12	In children with >10% BSA
		13	Burns to face, neck, chest with airway compromise
		Medical patients where the expertise of the crew is required:	
		14	Unstable myocardial infarction
		15	Refractory anaphylaxis
		16	Refractory seizures
		17	Unstable arrhythmias
	18	Neonatal emergencies requiring urgent upgrade in care to a Neonatal ICU or Neonatologist	
	19	Imminent ecclampsia	
	20	Life threatening medical conditions that require urgent intervention that is unavailable in the local facility	
	21	Where specialized equipment or expertise carried by the helicopter is required on scene	
	22	Where ALS is required and cannot be delivered by road in a reasonable time period	
	23	Where access to the scene is limited but a helicopter can safely be Landed	
	24	Mass casualty incidents where the local EMS resources are greatly exceeded by the number of priority 1 and 2 patients	

GENDER	1	MALE
	2	FEMALE

AGE	1	NEWBORN
	2	INFANT
	3	PAEDIATRIC
	4	ADULT

PRIMARY / IHT	1	PRIMARY
	2	IHT

BILLING	1	MEDICAL AID
	2	PROVINCIAL
	3	RAF
	4	WCA

RECEIVING HOSPITAL	

TYPE OF INCIDENT	1	Motor vehicle accident
	2	Motor bike accident
	3	Pedestrian vehicle accident
	4	Shooting
	5	Assault
	6	Falls
	7	Respiratory disorder
	8	Seizures
	9	Cardiac
	10	Unknown medical
	11	Scuba diving accident
	12	Industrial accident
	13	Domestic accident
	14	Fall from a horse
	15	Vascular
	16	Renal

	17	Neonatal transfer
	18	Sepsis
	19	Medical - other
	20	Crush injury
	21	Snake bite
	22	Boat accident
	23	Burns
	24	Coma
	25	Obstetrics
	26	Gynaecology
	27	Drowning / near-drowning
	28	Other - ???
	29	CVA

FLIGHT TIMES		To scene or referring hospital
		Land on scene or referring hospital
		Depart scene for receiving hospital
		Arrive at receiving hospital
		Return to base
		Land at base

CLINICAL PROCEDURES		**Airway**	
		1	Oral intubation
		2	Nasal intubation
		3	Blind nasal intubation
		4	Alternative airway device (LMA / DLA)
		5	Suctioning
		6	Needle cricothyroidotomy

		7	Surgical cricothyroidotomy
		8	Nil
	Breathing		
		1	Needle thoracentesis
		2	Intercostal drain
		3	Oxygen via mask
		4	Nebulisation
		5	Bag-valve-tube ventilation
		6	Mechanical ventilation
		7	BVT ventilation & mechanical ventilation
		8	Nil
	Circulation		
		1	CPR
		2	Peripheral intravenous cannulation
		3	External jugular vein cannulation
		4	Femoral vein cannulation
		5	Intraosseous cannulation
		6	Umbilical vein cannulation
		7	Pneumatic anti-shock garment
		8	Fluid resuscitation
		9	Central access
		10	Peripheral intravenous cannulation & fluid resuscitation
		11	Nil
	Other procedures		
		1	Nasogastric tube
		2	Orogastric tube

		3	Urinary catheter
		4	Defibrillation
		5	Cardioversion
		6	Pacing
		7	Incubator
		8	Capnography
		9	Pulse oximetry
		10	Capnography & Pulse ox
		11	Spinal immobilisation
		12	Splint fracture
		13	Other - ???
		14	Nil
		Pharmacology	
		1	Acetyl Salicylic Acid
		2	Adenosine
		3	Adrenaline
		4	Amiodarone
		5	Atropine Sulphate
		6	Calcium Chloride
		7	Calcium Gluconate
		8	Clonazepam
		9	Clopidogrel
		10	Clothiapine
		11	Dextrose 50%
		12	Diazepam
		13	Dobutamine
		14	Dopamine

		15	Enoxaparin sodium
		16	Etomidate
		17	Fenoterol
		18	Fenoterol / Ipratropium Bromide
		19	Fentanyl citrate
		20	Flumazenil
		21	Furosemide
		22	Glucagon
		23	Glycopyrrolate
		24	Haloperidol
		25	Heparin sodium
		26	Hydrocortisone
		27	Hyoscine butylbromide
		28	Insulin
		29	Ipratropium Bromide
		30	Ketamine
		31	Ketorolac
		32	Lignocaine Hydrochloride - local
		33	Lignocaine Hydrochloride - systemic
		34	Lorazepam
		35	Magnesium Sulphate
		36	Metaclopramide
		37	Midazolam
		38	Morphine
		39	Naloxone

		40	Neostigmine Methylsulphate
		41	Nitrolingual spray
		42	Nitrocine
		43	Pancuronium Bromide
		44	Paracetamol
		45	Parecoxib
		46	Phenylephrine
		47	Phenytoin Sodium
		48	Potassium Chloride
		49	Prochlorperazine
		50	Promethazine HCl
		51	Propofol
		52	Ranitidine
		53	Rocuronium Bromide
		54	Rosuvastatin
		55	Salbutamol - intravenous
		56	Salbutamol - nebulisation
		57	Sodium Bicarbonate 8,5%
		58	Sodium Valproate
		59	Suxamethonium Chloride
		60	Thiamine
		61	Thiopentone sodium
		62	Tilidene hydrochloride
		63	Vecuronium Bromide
		64	Morphine & Midazolam
		65	Nil

PATIENT OUTCOME AFTER 24 HOURS	1	Discharged
	2	Alive and stable
	3	Alive and unstable
	4	Deceased

PATIENT OUTCOME AFTER 72 HOURS	1	Discharged
	2	Alive and stable
	3	Alive and unstable
	4	Deceased

Appendix 6: Flight Assessment Form

HEMS FLIGHT ASSESSMENT

NETCARE 082 911

Patient	
Age	

Case no	1106120209
Medical Aid	

Ground crew	

Location	Ishawe - KZN
Closest appropriate facility	Umhlanga hospital
Distance/time by road	120km. But ALS has to drive from there first
Time for helicopter to arrive	36min
Transport time by air	36min

History	Gunshot left groin.

Vitals	BP	106/50	HR	120	SATS	94%	BR	

Weight			GCS	15/15

Clinical examination	Activelt bleeding from wound on posterior buttox - no arterial bleeding noted thus ? From pelvic vascular bed. Docter going to tie the pelvis
Additional notes	Case also discussed with
Call Authed/ Declined & Reason	Call Authed - Unable to treat patient at current fascility - needs upgrade of care and loose a lot of time transporting patient by road

Authorising doctor	
Completed by	

Date	12/06/2011

HEMS CALL OUT CRITERIA

1	Isolated head injury where the GCS is between 5 and 12	☐
2	Head injury with focal neurological fallout	☐
3	Initial blood pressure of less than 80 mmhg systolic	☐
4	Where signs and symptoms indicate a spinal injury and road transportation time exceeds 20 minutes or where extreme terrain prevents safe ground transport	☐
5	Patients with respiratory distress despite supplemental oxygen	☐
6	Amputations:Above knee or elbowWith significant vascular compromise	☐
7	Severe penetrating injury trauma to head, neck, thorax, and/or abdomen with possible involvement of the underlying organs or vascular structures	☐
8	Near drowning with neurological deficit or haemodynamic compromise	☐
9	Electrocution with unstable arrhythmia or neurological deficit	☐
10	Hypothermia (<35 deg Celsius) or hyperthermia (>40 deg Celsius)	☐
11	**Burns:**	☐
	In adults with 20-80% BSA	☐
	In children with >10% BSA	☐
	Burns to face, neck, chest with airway compromise	☐
12	**Medical patients where the expertise of the crew is required:**	☐
	Unstable myocardial infarction	☐
	Refractory anaphylaxis	☐
	Refractory seizures	☐
	Unstable arrythmias	☐
13	Neonatal emergencies requiring urgent upgrade in care to a Neonatal ICU or Neonatologist	☐ ☐
14	Imminent eclampsia	☐
15	Life threatening medical conditions that require urgent intervention that is unavailable in the local facility	☑
16	Where specialized equipment or expertise carried by the helicopter is required on scene	☐
17	Where ALS is required and cannot be delivered by road in a reasonable time period	☑
18	Where access to the scene is limited but a helicopter can safely be landed	☐
19	Mass casualty incidents where the local EMS resources are greatly exceeded by the number of priority 1 and 2 patients	☐

Appendix 7: Patient Report Form (EPRF)

TYPE	E-Admin	N	B	1106120057-200015180-Netcare3Helicopter

Netcare 911 **Patient Report Form**
Netcare 911 (Pty) Ltd
Co Reg No. 1998/006748/07 Practice No. 0901032

REGION		BASE	200015180	EMPLOYEE NAME	
AMBULANCE NO.	Netcare03	RV NO.		INV NO.	
DATE OF CASE	2011061214:29	DOD NO.		CASE NO.	1106120209

PATIENT'S NAME		TITLE	Mr	AGE	34	GENDER	M	RACE		ID	

TRANSPORTATION

TRANSPORTED FROM	ESHOWE PROVINCIAL HOSPITAL
TRANSPORTED BY	Netcare03
TRANSPORTED TO	UMHLANGA HOSPITAL
HOSPITAL NO.	
PERSON RECEIVING PATIENT	NAME

CREW DETAILS

MEMBER'S NAME	HPCSAReg

[redacted]

PAST HISTORY

ALLERGIES	None Selected
MEDICATION	Nil known
PAST MED/ SURG HISTORY	Not Selected
LAST MEAL	Breakfast
EVENTS PRIOR	Accidental gunshot wound through left femur

INCIDENT INFORMATION

Scene Address:	Eshowe Provincial Hospital CAS Kangela Street Eshowe,Kwazulu-Natal
Dispatch Info	GSW leg
On Arrival	CPR in progress
Main Complaint	Accidentally shot by friend whilst hunting. Entry left thigh. Exit inferior right gluteus. No record

PRIMARY SURVEY

A	Clear		Maintainable	x	Intubated		Surgical		ETT Sz	0.00	MmID Depth	0	cmT

B Trachea	Central	Air Entry:	Clear Bilaterally
Extra Sounds	Normal		
Mechanics	Assistant Ventilation		
Neck Veins	Flat		

HaemorrhageSite	HaemorrhageVolume
Leg (Right)	<50ml
Leg (Left)	>500ml
Pelvis	100-500ml

Pulse Site:	Carotid	Pulse Charac	Absent	Pulse Site Rhythm	Irregular
Perfusion:	Poor	Colour:	Pale	Cap Refill	> 3 sec

D Initial GCS 3 /15 E 1 /4 M 1 /6 V 1 /5 or A | | V | | P | | U | x

Spinal Motor Functions:	Unable to assess
Sensory Level	Unable to assess

PROCEDURES

ALIGNMENT		BREATHING	
LOGROLL		OXYGEN	
VEHICLE EXTRICATION		CHEST DECOMPRESSION	
SPINEBOARD		PULSE OXIMETRY	x
SCOOP		VENTILATION	x
CERVICAL COLLAR		**CIRCULATION**	
HEADBLOCKS		E.C.G	x
SPIDER HARNESS		I.V ACCESS	x
KED		I.O. ACCESS	
		HI CAP LINE	
AIRWAY		PACING	
SUCTION		C.P.R	x
OROPHARYNGEAL AIRWAY	x	COLLOIDS	
ORAL E.T.T	x	DIAL-A-FLOW	
NASEL E.T.T		**MISCELLANEOUS**	
SURGICAL AIRWAY		URINE CATHETER	x
		GASTRIC TUBE	x
		INCUBATOR	

SECONDARY SURVEY

Head and Face	Patient apnoeic, unresponsive, no carotid pulses felt. No obvious head injuries noted.
Neck	JVP flat, no obvious injuries noted. Trachea central. No bruits, subcutaenous emphysema, swellings
Chest	No heart sounds heard. No obvious signs of tamponade. Air entry equal bilaterally with assisted ventilation with BVM at 12 / minute. No signs of trauma.
CVS	Heart sounds absent. No recordable blood pressure. No palpable central or peripheral pulses. Slow PEA on rhythm strip on ECG. No obvious signs of trauma.
Abdomen	Soft and non-tender with no signs of trauma.
Pelvis	Ecchymosis of entire perineal area. Scrotum also discoloured blue, glans swollen. 1 x 2cm wound right inferior gluteal margin. No active bleeding. No contamination. No bruits around wounc
Extremities	Active bleeding noted from 3cm irregular wound left thigh below inguinal ligament mid-point. Wound covered by pressure dressings but still bleeding through. No distal pulses felt on left leg. Thrill f
Spine	Not examined in detail but no obvious wounds noted

DIAGNOSIS: (ICD 10 CODE) — Priority

ICD 10 Code	1

Next Of Kin Details

Name		Contact Number		Legal Representative	
Surname		Contact Email		Relation	

VITAL SIGNS

BREATHING						CIRCULATION						DISABILITY					RTS. /12				
RateMin BR	B R Rhythm	B R AirEntryL	B R AirEntryR	B RFi02	B RSa02	CL Heart Rate	CL Rhythm	CL Perfusion	CL BP	ECG Analysis CL	GCS	Pupil Size L	Pupil Size R	Pupil Reaction L	Pupil Reaction R	Temp	Glucose	Pain Score	Date \ time:		
12	Regular	Clear Bilaterally	Clear Bilaterally	0.8	<80	32	Irregular	Poor	Unrecordable	PEA	3	2	2	None	None	Cool	5.8	0	6/12/11 12.40		
12	Regular	Clear Bilaterally	Clear Bilaterally	0.8	<80	48	Irregular	Poor	Unrecordable	PEA	3	2	2	None	None	Cool	5.8	0	6/12/11 12:50		
12	Regular	Clear Bilaterally	Clear Bilaterally	0.8	<80	58	Irregular	Poor	Unrecordable	PEA	3	2	2	None	None	Cool	5.8	0	6/12/11 13.00		
12	Regular	Clear Bilaterally	Clear Bilaterally	0.8	<80	113	Irregular	Poor	Unrecordable	PEA	3	2	2	None	None	Cool	5.8	0	6/12/11 13.10		
12	Regular	Clear Bilaterally	Clear Bilaterally	0.8	<80	107	Irregular	Poor	Unrecordable	PEA	3	8	8	None	None	Cool	5.8	0	6/12/11 13:15		

FLUID ADMINISTERED

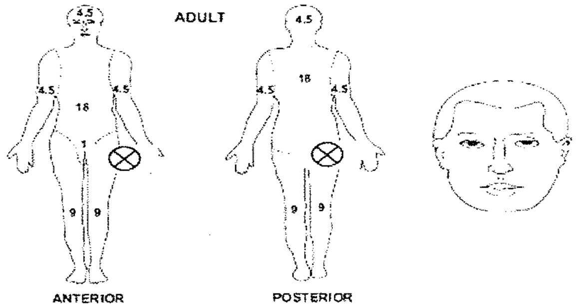
Fluid	Fluid Administration Set	Rate	FATime	FluidNeedleGaug	Site	Volume
Ringers Lactate	60 Dropper	fast	12-Jun-2011 12.30	18 G	R Arm	2,000
Volvuven	60 Dropper	fast	12-Jun-2011 12.30	18 G	R Arm	500

MEDICINE ADMINISTERED

Medicine	Dose	MATime	Route	Name	Surname	HPCSAReg	SignatureImage
Scoline	100mg	12-Jun-2011 12:47	IV				
Adrenaline	1mg	12-Jun-2011 12:47	IV				
Adrenaline	1mg	12-Jun-2011 12.50	IV				
Adrenaline	4mg in 2	12-Jun-2011 12.55	IV				
Atropine	1mg	12-Jun-2011 12.55	IV				

INJURED LEGEND

Dislocation	Fracture	Open Fracture	GSW	Stab Wound	Laceration	Abrasion	Burns
/\/\	#	(#)	⊗	Ø	/	/////	XXX



Burn surface area : 0 %

Depth:

Superficial : Prtial: Full Thickness:

FLUID LOSS (ml)

1500

Total. 1,500

ECG ANALYSIS

PEA

ECG STRIP . No

PACING

	Demand	Fixed
TIME1: RATE1: mA1:	(1)	
TIME2: RATE2: mA2:	(2)	
TIME3: RATE3: mA3:	(3)	

DEFIB		CARDIOVERSION	
DCTime	DCJoules	DCTime	DCJoules

ADDITIONAL NOTES

ICD 10 Code Description:Gunshot left thigh

Arrived at Eshowe Hospital and immediately taken to casualty by friend of patient as patient had apparently arrested. Arrived into casualty at 12:38. Patient apnoeic and being bagged by at rate of 12 / minute but without adequate mask seal. Advised same appropriately. Hadover from Patient was GCS 14/15 but now no pulse and was preparing to intubate. Advised her to commence chest compressions immediately after confirming pulselessness and a slow small complex rate of approximately 32-35. HQ-CPR commenced by whilst I prepared to intubate patient. No gag but clenching with GCS 3/15. Identified as crash airway scenario. No obvious predictors for difficult airway noted (MOANS/LEMON/RODS/SHORT) and confirmed adeqaute mask seal and good ventilations

VG 1158 Eshowe 1232 Eshowe 1327 VG 1409 Total flying time 1.3

PATIENT VALUABLES

VALUABLES RECEIVED FROM PATIENT:

HANDED TO:

SIGNATURE:

PAST HISTORY - CONTINUED

EVENTS PRIOR: Accidental gunshot wound through left femur

SECONDARY SURVEY - CONTINUED

Chest: No heart sounds heard. No obvious signs of tamponade Air entry equal bilaterally with assisted ventilation with BVM at 12 / minute. No signs of trauma.

CVS Heart sounds absent. No recordable blood pressure. No palpable central or peripheral pulses Slow PEA on rhythmj strip on ECG No obvious signs of trauma

MANAGEMENT

Full cardiorespiratory monitoring
Saturation monitoring
Cardiopulmonary resuscitation
Intubation
Rapid sequence paralysis only
Inotropic support
Orogastric tube
Foleys catheter
Wound tamponading using foleys catheters

E-ADMIN OPERATORS

Case Management Employee:	
Validation Employee:	

Appendix 8: Flight Follow Up

HEMS FOLLOW-UP

NETCARE 082 911
24HR EMERGENCY MEDICAL ASSISTANCE

Date of case	29-Jul-11		
Patient name		**Case number**	1107290276
Authorising doctor			

Person requesting Helicopter			
Referring facility/Scene address	Howick		
Receiving facility	St Anne's	**Receiving doctor**	

Diagnosis	Polytrauma, fall from height

Flight crew	

24 HOUR FOLLOW-UP

Hospital	St Anne's	**Tel nr**	0338975000
Ward	Level 2	**Hosp nr**	T307004
Information received from	Sister in ward		

Pt well, awake, mobilizing. Only positive finding on investigations is an upper lobe consolidation on CXR.

Flight crew informed	No
Ground crew informed	No

Date	30-Jul-11
Doctor	

72 HOUR FOLLOW-UP

Hospital	St Anne's	**Tel nr**	0338975000
Ward	Level 2	**Hosp nr**	T307004
Information received from	Sr in charge		

Patient was discharged yesterday.

Flight crew informed	to be emailed
Ground crew informed	-

Date	01-Aug-11
Doctor	

Appendix 9: Flight Log

Netcare 911 Flight Times (Per Call)

Pilot 1:		Doctor:	
Pilot 2:		Paramedic:	
Date:			
Case no:	1106120209		
Netcare:	3		
Primary:			
IHT:	X		
Ferry:			

	Place	Time	Flight Time
Take Off	FAVG	11H58	
Land	ESHOWE	12H32	0.6

	Place	Time	Flight Time
Take Off	ESHOWE	13H27	
Land	FAVG	14H09	0.7

	Place	Time	Flight Time
Take Off			
Land			

	Place	Time	Flight Time
Take Off			
Land			

	Place	Time	Flight Time
Take Off			
Land			

Total	**1.3**

NB: All times should be entered in 6 minute intervals for ease of reference

Total flight time must equal Capt log total

Appendix 10: Netcare 911 Confidentiality Agreement

Confidentiality and Non-Disclosure Agreement

I, Mrs Dagmar Muhlbauer, hereby acknowledge my involvement as the researcher in the research project entitled: An Analysis of Patients Transported by a Private Helicopter Emergency Medical Service within South Africa. As part of this study, I will be accessing confidential patient information off of the Netcare 911 CARS database. This information will not be utilized for any other purpose other than this research project and at no stage will any patient identifying data be utilized in the write-up. Each clinical record will be assigned a number and no patient identifying data will be recorded. All data will be collected and entered into an electronic spread sheet that will be password protected.

Signed this 19 of June 2012 at Netcare 911 SECC

[redacted]

Signature