FACTORS THAT INFLUENCE THE RECOVERY OF PHYSICAL FUNCTION OF ADULT PATIENTS WITH MAJOR BURN INJURIES

by

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Physiotherapy

Johannesburg, 2020

DECLARATION

I, *Irene Katherine Angelou*, declare that this research report is my own work. It is being submitted for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University

06/04/2020

Signed **Date**

ABSTRACT

Background: Research focusing on patients with major burn injuries is limited, and this applies specifically to the physiotherapy aspects and functional outcomes relating to burns. This study was done so as to review the patients with major burn injuries, their outcomes and the effects of certain aspects of the hospital stay on physical function during the different periods of the hospital stay.

Objectives: The objectives laid out were set to describe the demographic and clinical characteristics of patients with major burn injuries; to describe the changes in physical function of patients with major burn injuries from the respective stages starting with their Intensive Care Unit (ICU) admission until their discharge from hospital; to describe the number as well as the type of complications that patients with major burn injuries develop during their stay in the ICU; to determine whether the severity of injury is associated with physical function at discharge from the hospital; to determine whether there is an association between the complications developed in ICU and physical function at hospital discharge; to determine if the number of surgical procedures performed is associated with physical function at hospital discharge; and to determine if the length of stay is associated with physical function at hospital discharge.

Design: A retrospective record review was conducted to meet the objectives of this research study.

Methods: The study population included adults who had sustained major burn injuries. Information about these patients was sourced from a private hospital in Johannesburg, South Africa, which has a Level 1 Trauma Centre and a Burns Unit. The recorded data in the patients' ICU charts, hospital files and physiotherapy notes were reviewed and only the information needed for this study was extracted. All of the records of patients admitted to the Burns Unit and who were subsequently transferred to a hospital ward were reviewed over a period of 36 months. Patients diagnosed with burns of a total body surface area (TBSA) of 20% or more (excluding superficial burns), with or without an inhalation injury (Gauglitz and Williams, 2016) were included. Records that were excluded from the study included the following cases: patients with complex lower limb injuries, patients with cognitive disorders, and patients who had died in hospital.

Results and Discussion: Eighty-four patients were admitted to the hospital during the study period. Of these 84, 73 fitted the inclusion criteria. Though many of the results were incomplete, the following was found. The resulting majority of these patients were male, of black ethnicity, and with a median age of 38 (IQR:22). The most common mechanism of injury was of a thermal nature. The median TBSA burned was 31%, the most common body part to be injured being the upper

limbs. The results of this study are comparable to those of others conducted in South Africa. According to the demographics and clinical characteristics, the majority of the study cohorts were males, of a black ethnicity, and the areas that were most frequently burned were the limbs (Den Hollander, et al. 2014). Injury to the limbs could be linked to injury on duty as there is evidence that burn injuries generally occur at work e.g. from flammable substances. Furthermore, it was noted that work-related injuries predominantly involve the extremities (Forjuoh, 2006; Hanekom, et al. 2015; WHO, 2019a). Burn injuries can also be sustained at home and during leisure-time activities.

The median Injury Severity Score (ISS) was 16 (IQR:16) and the mean revised Baux score was 93 (SD:19.3). Taking into account the revised Baux score, it becomes evident that the majority of the study population (at least 50%) were found to be at risk of mortality, with some individuals potentially needing palliative care.

Length of stay (LOS) ranged from seven days, with a maximum of 243 days. The most surgeries a patient underwent amounted to 29. The most common surgery was a debridement. The most common complication with 21.7% (n=15) of the sampled patients was oedema. Other complications included pyrexia (18.8%), low haemoglobin (15.9%), diarrhoea (14.5%), blisters and infection (11.6%). An extended LOS allows for rehabilitation in the hospital and healing after the surgeries (e.g. skin grafts) and from the mentioned complications. With regard to the surgeries, it is evident that the primary cause of surgery was for wound management. Oedema may be due to IV fluid overload, increased capillary permeability as well as blood flow slowing in that area. Pyrexia may be due to the disturbance in thermoregulation, increased metabolic response, systemic inflammation, or an infection. Low haemoglobin levels might have been due to blood loss through the wounds sustained at the time of the injury, multiple debridement procedures as part of wound care, and phlebotomy procedures performed in the ICU. The reasons for vomiting and diarrhoea were probably due to the medication given to the patients in the Burns Unit (e.g. opioids cause vomiting and constipation, and antibiotics cause diarrhoea).

Of the study cohort, 43.8% (n=32) of the patients were intubated and ventilated and 45.2% (n=33) needed sedation. Mechanical ventilation is usually accompanied by sedation. Sedation is necessary for patient comfort in an ICU clinical setting, and was found to be essential in this patient population for pain management as a result of their injuries and particularly subsequent to painful surgeries (e.g. debridement). The injuries sustained and subsequent surgeries may affect the range of motion of the joints involved.

Restriction of motion of the hand/wrist was noted as the most frequent consequence. The general trend for ROM seemed to improve over the hospital stay although limited ROM of the knees, ankles and feet for some patients were noted at hospital discharge. The possible reasons for decreased ROM over the period ranging from ICU discharge to hospital discharge might have been due to the lack of patient compliance (not compliant with physiotherapy sessions or exercises that were to be done independently), the need for joint immobility and for multiple surgeries.

Muscle strength also seemed to improve during the patients' hospital stay. All patients received physiotherapy management during their hospital stay, and it is reasonable to conclude that they responded clinically to the rehabilitation received for regaining their muscle strength. The muscle length of the Achilles tendon was the most common of the two-joint muscles to be shortened.

Distance walked, independent mobilisation, stair climbing and the Functional Status Score (FSS-ICU) seemed to improve throughout the hospital stay and can be attributed to the fact that patients received needs-based physiotherapy care.

No associations were found between ISS, ICU LOS, number of theatre visits, and number of complications developed respectively, and non-independent physical function of patients. Since surgeries are conducted to improve the patient outcomes, it seems plausible that no associations were found between the number of surgeries and non-independent physical function of patients at hospital discharge. On the other hand, LOS might have improved physical function as the patient's functional ability would have reached a certain level before he/she could be discharged from the hospital.

Limitations of this study include:

- poor data recording,
- the non-recording of the number of times a single complication occurred,
- the non-recording of psychological aspects and level of pain, and
- the intervals between which the data were recorded were too great.

Conclusion: This retrospective record review provides a general overview of the outcomes associated with patients recovering from major burn injuries. The findings should be interpreted with caution as the sample is small and some records were incomplete. Physical function at hospital discharge for this cohort does not seem to be associated with ISS, ICU LOS, hospital LOS, theatre visits number and number of complications developed respectively. Information obtained from this study provides a platform from which further research of a prospective nature can be conducted to investigate factors that might influence physical recovery of patients who survive major burn injuries.

ACKNOWLEDGEMENTS

- I would like to extend my special thanks to Professor Heleen van Aswegen for her insights, support and guidance.

- I would like to thank the Hospital at which this study was conducted, as well as the people involved, that made this study possible.

- A big thank you goes to the trauma research nurse, Rene Grobler, and the physiotherapy practice owner, Moira Wilson, for their involvement in this study.

- I would like to thank Vanessa de Boer and Irene Janse Van Noordwyk for their editing services.

- I would also like to thank my family and friends for the love and support they have given me throughout this period.

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LIST OF ABBREVIATIONS

ACBT	- Active Cycle of Breathing Technique
ADL	- Activities of Daily Living
ATLS	- Advanced Trauma Life Support
DALY	- Disability-Adjusted Life Year
FSS-ICU	- Functional Status Score for ICU
ICU	- Intensive Care Unit
ISS	- Injury Severity Score
LOS	- Length of Stay
PEP	- Positive Expiratory Pressure
QOL	- Quality of Life
ROM	- Range of Motion
TBSA	- Total Body Surface Area
WHO	- World Health Organization

CHAPTER 1

1. INTRODUCTION

1.1 BACKGROUND

A person could sustain a traumatic injury through blunt or penetrating injury, drowning, poisoning, a motor vehicle accident, a pedestrian vehicle accident, burning, a fall, violence (self-inflicted, assault or war), or machinery (Clark et al. 2013; World Health Organisation (WHO), 2010; WHO, 2019). A worldwide estimation of deaths caused by trauma amounted to 9% to 10% annually which equates to 5.8 million people (3.8 million on account of unintentional injury), a whole 32% more than the collective of human immunodeficiency virus, tuberculosis and malaria (Norman et al. 2007; Holtslag et al. 2008; Chandran, Hyder and Peek-Asa, 2010; WHO, 2010; Hardcastle et al. 2016; WHO, 2019). The leading cause of death is traumatic injury in adults under the age of 45 years (Norman et al. 2007; Holtslag et al. 2008; Chandran, Hyder and Peek-Asa, 2010; WHO, 2010; Hardcastle et al. 2016; WHO, 2019). One fifth of traumatic deaths are found to occur in Africa (Hardcastle et al. 2016).

Some populations are more susceptible to injury than others and the statistics differ according to gender, age, income and region (WHO, 2010). This is echoed by noting that between the ages of five and 44 years, injury is considered one of the first three causes of death. Furthermore, the rate of death is higher in lower-income countries (over 90% in low-to middle-income countries); and half the number of women as opposed to the number of men die on account of an injury (Norman et al. 2007; Chandran, Hyder and Peek-Asa, 2010; WHO, 2010). Norman et al. (2007) noted that the highest rate of mortality attributable to injury occurs in women in India and Africa, and in men in the middle-to low-income countries in Africa. Injury threatens the health of each population globally leaving most of the injured with disabilities that are either temporary or permanent (WHO, 2019). The WHO (2010) has noted, that on a global scale, injuries are the cause of 16% of disability, with unintentional injuries causing a 138 million disability-adjusted life-years (DALYs) loss (Chandran, Hyder and Peek-Asa, 2010; de Ramirez et al. 2012). In the middle-to low-income countries, one of the main causes of DALYs lost is burn injury (WHO, 2019a), specifically burns caused by fire (den Hollander et al. 2014). In South Africa, the secondary cause of DALYs lost is due to unintentional injuries and violence (Seedat et al. 2009). Burns account for 10 million DALYs on a global scale (Wood, 2015). No research results regarding DALYs in South Africa in patients with burn injuries could be found.

Noordin, Wright and Howard (2008) define DALY as the sum of healthy years of life lost owing to premature mortality and years alive with disability ‘’adjusted for severity’’. It is a measure that summarises health across regions and time, quantifying the burden of disease (Polinder et al. 2012; GBD 2015 DALYs and HALE Collaborators, 2016; Crowe et al. 2019). Noordin, Wright and Howard (2008) continue to explain that one DALY is equated to one year of a healthy life lost. Crowe et al. (2019) states that in 2016, the female and male DALYs were 64 and 93 respectively. The rate of disability in females is lower than that of males and it is important to note that short- and long-term disabilities may differ with every burn injury. Global DALYs have not significantly changed between the years 1990 and 2015 (GBD 2015 DALYs and HALE Collaborators, 2016). There has, however, been an increase in DALYs in particular regions on account of increasing interpersonal violence, non-communicable disease, and war in those regions (GBD 2015 DALYs and HALE Collaborators, 2016). In noting this, it has been suggested by Haagsma et al. (2016), that the global DALY has steadily declined from 1990 to 2013 even though the rate of injury still remains high in some regions. A reason for the decreased DALYs after a burn injury might be due to the increase in the average age of those who incur burn injuries, as well as to the reduction in the burn injury incidence (Crowe et al. 2019). This effectively leaves a decreased number of years of loss of life, as well as a decreased period of disability (Crowe et al. 2019).

South Africa’s second leading cause of death and DALYs lost is due to injury and violence (Seedat et al. 2009). It has been said that South Africa has a “quadruple burden” of diseases resulting in deaths, traumatic injury being but one part of this burden (Norman et al. 2007). The other three include the ‘’pre-transitional diseases’’ related to chronic diseases, poverty and development, and human immunodeficiency virus (Norman et al. 2007).

Burn injuries are morbidly distressing since they cause varying degrees of morbidity (physical disability), emotional upheaval (mental repercussions), and impaired quality of life (QOL), Globally, they cause approximately 180 000 deaths per year and are also the leading cause of morbidity in cases that are not fatal (Forjuoh, 2006; Smolle et al. 2017; WHO, 2019a). Forjuoh (2006) noted that an estimated 1.1 per 100 000 of the population had an incidence of injuries associated with fire in the low- to middle-income countries. Smolle et al. (2017) noted a declining trend in burn injuries in South Africa. Burn injuries do not only affect a patient’s health but also add socio-economic stress to the patients and their families (Smolle et al. 2017). There are 138 low- to middle-income countries as laid out by the World Bank for example Botswana, Cameroon, China, Mozambique, South Africa, Sri Lanka, Thailand, Turkey and Zimbabwe, and more (World Bank Group, 2019).

Mortality from a burn injury in high-income countries is nine times lower than that in the middle- to low-income countries (Van Niekerk, Laubscher, and Laflamme, 2009). This has been reiterated by Tang et al. (2016), Smolle et al. (2017) and the World Health Organisation (WHO) (2019a). These sources mentioned that burn injuries occur more commonly in countries that are still developing and that have a lower socio-economic status (middle to low). Men have a higher probability of sustaining burn injuries, but recently women with burn injuries have been reported to be presenting with a higher death rate than men (Smolle et al. 2017; WHO, 2019a). Burn injuries predominantly occur in the workplace (20-25% of the major burn injuries), home or outdoors, with most of the causes including thermal injury (e.g. through scalding or fire), and the remainder being attributed to electricity, chemicals, ionizing radiation, ultraviolet radiation and non-electrical appliances that are being used for cooking, lighting, and heating (Forjuoh, 2006; Hanekom et al. 2015; WHO, 2019a). Children, women and the elderly are seen to be the most susceptible to burn injuries (Hanekom et al. 2015). In adulthood, the rate of burn injuries peaks between the ages 30 to 39 years, largely due to the inappropriate use of materials that are flammable (Forjuoh, 2006). Research also shows that burns are sustained more frequently at the commencement of an occupation (Forjuoh, 2006).

Other burn injury risk factors include overcrowding, with a lack of the correct safety measures in place, poverty, substandard living conditions, medical conditions (e.g. neurological conditions), falls, smoking, diabetes, cardiac disease, flammable clothing, chronic diseases, substance abuse, a lack of maternal education, illiteracy, chemicals, gas appliances, paraffin lamps, cooking pots, candles, open fires, hot liquids, and the improper use of petroleum and electricity. Of these factors, hot liquids and open fires are the most common causes of burns (Hettiaratchy and Dziewulski, 2004; Forjuoh, 2006; den Hollander et al. 2014; Hanekom et al. 2015; Wood, 2015; Tang et al. 2016; WHO, 2019a). In the elderly, it has been noted that co-morbidities (the side-effects of medication) and frailty (limited co-ordination) are risk factors for burn injury, while for children, the absence of supervision and impairments prior to the burn injury (Hanekom et al. 2015) are more prevalent.

In South Africa, burn injuries may be unintentional, self-inflicted (e.g. a suicide attempt), or sustained as a result of an assault or abuse (Forjuoh, 2006). Forjuoh, (2006) stated that mainly the upper limbs are affected by burns (except flame burns), and subsequently the lower limbs, although not many studies report on the location of the burn. The burning of the victim’s clothing principally affects the lower limbs (Forjuoh, 2006).

More than 95% of burn injuries worldwide are unintentional (Hanekom et al. 2015). Unintentional injuries are generally due to burns by fire, which cause 10% of deaths (den Hollander et al. 2013). Rode, Berg and Rogers (2011) mentioned that 21 million South African homes (middle- to low-income) use kerosene as an energy source, which is related to many of the household fires in this country. In the Western Cape study, by Maritz (2012), it was reported that 21% of the admissions to hospital were due to injuries sustained from fuel stoves and fires in shacks. Maritz (2012) was of the opinion that 71% of the burns were due to the use of kerosene stoves, with an additional 24% due to gas stoves.

The WHO (2019a) has noted that South Africa spends 26 million dollars (US) alone on care for patients with burn injuries from kerosene cooking stove incidents. The Medical Research Council has indicated that in South Africa patients with thermal burn injuries annually make up 3.2% of the population, 14% of which are classified as moderate to severe leading to patient hospitalisation (0.32% of the population - i.e. approximately 34 621admissions in KwaZulu-Natal alone) (Rode, Berg and Rogers, 2011; Rode et al. 2013; den Hollander et al. 2014).

Most burn injuries are sustained in the poorer regions, with a mere six percent of these cases being admitted to private hospitals (Rode et al. 2013). In a study conducted in a regional hospital in South Africa, burns patients (without or with other forms of trauma) endured an average hospital length of stay of 9.1 days (Pape, Swart and Duvenage, 2019). Another study noted the length of stay in hospital to equate to approximately one day per percentage of the total body surface area (TBSA) burned (Van der Merwe, 2008; Pape, Swart and Duvenage, 2019).

On admission to hospital, the patient with a burn injury is managed according to the principles of resuscitation outlined by Advanced Trauma Life Support (ATLS). This includes a primary and secondary survey identifying any injuries that are life-threatening, thereby allowing the appropriate management of such injuries (e.g. through the intensive care unit (ICU) or theatre) (Hanekom et al. 2015). The severe cases are treated at one of the six specialist burn centres in South Africa (Rode, Berg and Rogers, 2011; Giaquinto-Cilliers, 2014). However, most cases are admitted to general or district hospitals, which may pose a serious health concern for patients with burn injuries in respect of morbidity and the development of physical and psychosocial disabilities (Rode, Berg and Rogers, 2011; Giaquinto-Cilliers, 2014).

Complications that might develop in patients with burn injuries include lung complications (acute respiratory distress syndrome, pneumonia), skin graft failure, the formation of contractures (joint deformity, decreased ROM), the development of hypertrophic scarring, amputation (difficulties with activities of daily living), pruritus, muscle mass loss (muscle protein breakdown due to injury or development of ICU acquired weakness), sensory complications, and sepsis (Dyster-Aas et al. 2007; Esselman, 2007; Tirumala et al. 2013; den Hollander et al. 2014). Rising mortality rates, the improper treatment of a patient with a burns injury, and complications associated with burn wound healing, are impacted upon by staff shortages, inadequate infrastructures and the deprivation of resources in South Africa, and other developing countries (Giaquinto-Cilliers, 2014). Mortality rates and complications that are noted in this study are particular to patients with major burn injuries.

Major burn injury is defined as a burn injury to 20% or more of the TBSA (excluding superficial burns), and with more than five percent being full thickness injuries (Hettiaratchy and Papini, 2004; Borke, Zieve and Ogilvie, 2016; Gauglitz and Williams, 2016). This is compounded by inhalation injuries or major trauma, high voltage electrical burns, chemical burns, and lastly, second-degree burns over the major joints, buttocks, feet, face or hands (Hettiaratchy and Papini, 2004; Borke, Zieve and Ogilvie, 2016; Gauglitz and Williams, 2016). Major burns could cause a patient to live with long-term complications related to the psychological and physical aspects of their QOL (Fauerbach et al. 2007; Tirumala et al. 2013; Giaquinto-Cilliers, 2014; Moi et al. 2016; Tang et al. 2016).

Regarding the management of patients with burn injuries, the depth of the burn, the location of the wound, its extent, the associated complications and related injuries, patient age, and the premorbid level of activity and morbidities are considered (Spires et al. 2007). It is important for the multidisciplinary team to try their utmost to prevent complications from developing during patient recovery.

The physiotherapeutic management of patients with burn injuries that are dealt with in acute-care settings includes the following:

- facilitating airway humidification to aid mobilisation and the expectoration of retained secretions (particularly important in those with inhalation injuries),
- improving the patient’s cough effort, lung volume, lung compliance, oxygenation, and
- strengthening the respiratory muscles of those with a prolonged ICU length of stay (LOS) to facilitate the weaning of the patient from mechanical ventilation (Hanekom et al. 2015).

Musculoskeletal system management includes the following:

- improving and maintaining passive joint ROM (including the use of splinting and positioning where needed),
- improving muscle power,
- maintaining and improving the functional ability and exercise capacity of the patient (Hanekom et al. 2015).

1.2 PROBLEM STATEMENT AND JUSTIFICATION FOR STUDY

South Africa's second leading cause of death is due to injury and violence with an estimated 1.1 per 100 000 of the population sustaining injuries associated with fire, as noted in the Western Cape alone, 21% of hospital admissions were due to fuel stoves and shack fires (Forjuoh, 2006; Seedat et al. 2009; Maritz, 2012). As described above, South Africa has a high prevalence of patients who experience trauma and burn injury. Thus, many patients require admission to specialised health-care centres for the management of their injuries. During hospitalisation, patients with major burn injuries receive physiotherapeutic management. Inpatient physiotherapy management includes a vast number of service provisions in the ICU setting and the ward setting as mentioned previously.

There is a dearth of evidence related to patients with burn injuries and rehabilitation in the acute-care settings. The prevailing evidence is very limited and deals mostly with pain management strategies and medical and surgical interventions for patients with burn injury. Little is known regarding the factors that affect the recovery of physical function in patients recovering from major burn injury during their hospitalisation. In order to prevent complications from arising after a major burn injury, a firm understanding of specific factors that place patients with such injuries at risk of developing complications is important. These complications include deformities and contractures, which could negatively influence their recovery of function by hospital discharge.

1.3 RESEARCH QUESTION

Which factors influence the recovery of the physical function of adult patients with major burn injuries during their hospital stay?

1.4 SIGNIFICANCE OF THE STUDY

The identification of factors that during hospitalisation potentially influence the recovery of physical function in patients with major burn injury will assist physiotherapists to identify those patients who are at greater risk and in developing patient-specific management plans for these patients in an attempt to optimise their recovery of physical function by the time that they are discharged from the hospital.

1.5 RESEARCH AIM

To determine the factors that influence the recovery of physical function in adult patients with major burn injuries during hospitalisation.

1.6 RESEARCH OBJECTIVES

1.6.1 To describe the demographic and clinical characteristics of patients with major burn injuries.

1.6.2 To describe the changes in physical function of patients with major burn injuries from admission to ICU until discharge from hospital.

1.6.3 To describe the number and type of complications that patients with major burn injuries develop during their ICU stay.

1.6.4 To determine whether there is an association between severity of injury and physical function at hospital discharge.

1.6.5 To determine whether there is an association between complications developed in ICU and physical function at hospital discharge.

1.6.6 To determine whether there is an association between the number of surgical procedures performed and physical function at hospital discharge.

1.6.7 To determine whether there is an association between length of stay and physical function at hospital discharge.

1.7 STUDY DESIGN

A retrospective record review was conducted to meet the objectives of this research study.

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

The information sourced for this study included the following databases, namely: Google Scholar, PEDro, PubMed, AccessPhysiotherapy, WebMD, EBSCO, CINAHL, ClinicalKey, Ovid/Wolters Kluwer, Physiopedia, Science Direct and SCOPUS. The majority of this information was sourced and researched over a period of 16 years up to and including 2020. The main keywords used included but were not limited to ‘major burn injury’, ‘physiotherapy’, ‘burns classification’, ‘burns epidemiology’, ‘physiotherapy burns treatment’, ‘revised Baux score’, ‘burns surface area’, ‘skin graft’, ‘escharotomy’, ‘fasciotomy’, ‘excision burns’, ‘inhalation injury’, ‘DALY burns’, ‘incidence of burns in South Africa’, ‘incidence of trauma’, ‘trauma incidence in South Africa’, ‘functional assessment for burns score’, ‘functional assessment in ICU’, ‘injury severity score’, ‘ventilation/perfusion (V/Q) mismatching’, and ‘burns physiotherapy’. The key concepts that will be focused on in this literature review include the types of burn injury, depth of tissue injury, local and systemic bodily responses to burn injury, management of patients using international advanced trauma life support guidelines, objective outcome measures, surgical burn management, burn injury complications that develop during hospital stay, physiotherapy management as well as record keeping and medico-legal implications.

As mentioned previously, the definition of a major burn injury is a burn injury to 20% or more of the TBSA (excluding superficial burns), with more than five percent being full thickness (Hettiaratchy and Papini, 2004; Borke, Zieve and Ogilvie, 2016; Gauglitz and Williams, 2016). It is compounded by major trauma or inhalation injury, high voltage electrical burns, chemical burns, and lastly, includes second-degree burns over major joints, the buttocks, feet, face or hands (Hettiaratchy and Papini, 2004; Borke, Zieve and Ogilvie, 2016; Gauglitz and Williams, 2016). Injury to the skin as well as any other bodily tissues caused by a burn is traumatic and is mainly caused by thermal injury, as well as by the other exposures discussed below (Hanekom et al. 2015). In burn injuries, caustic chemicals, heat, electricity, and cold, destroy the cells of the tissues (Hanekom et al. 2015).

2.2 TYPES OF BURN INJURY

2.2.1 Thermal Injury

Thermal burn injuries are commonly related to steam, hot liquids, flames (50% of adult burns) and hot solid objects (Hettiaratchy and Dziewulski, 2004; Hanekom et al. 2015). The burn depth is associated with the skin thickness, temperature on contact, and duration of contact (Orgill, 2009; Hanekom et al. 2015). Owing to the slow conductivity of the skin, thermal burns mostly affect the epidermis and dermis (Hettiaratchy and Dziewulski, 2004; Orgill, 2009; Hanekom et al. 2015). However, contact burns are regarded as full thickness burns (Hettiaratchy and Dziewulski, 2004; Orgill, 2009; Hanekom et al. 2015). Necrosis and eschar ("dead and de-natured dermis") form at the area that was at the heat source and could cause an irreversible injury (Orgill, 2009; Hanekom et al. 2015). Below this area, oedema occurs and the blood flow slows (Orgill, 2009). Healing and the need for surgical procedures are dependent on the depth of the burn injury (Hanekom et al. 2015).

Burn injuries could also be caused by cold temperatures, which cause damage to the tissues in that ice crystals damage the cells and cause a hypertonic environment (Hanekom et al. 2015). This interrupts the blood flow, which causes vascular thrombosis and hypoxia to the tissues (Hanekom et al. 2015).

2.2.1.1 **Inhalation injury**

An inhalation injury is the aspiration of vastly-heated gases or chemicals, hot liquids, or steam; and can be adjunct to other burn injuries (Palao et al. 2009; Hanekom et al. 2015). The risk of death increases by 20% in a patient with an inhalation injury and the associated complications (e.g. pneumonia) (Hanekom et al. 2006; Mlcak, Suman and Herndon, 2006; Hanekom et al. 2015). In fact, inhalation injuries are becoming the leading cause of mortality regardless of the age of the patient and the extent of the TBSA burned (Hanekom et al. 2006; Mlcak, Suman and Herndon, 2006; Hanekom et al. 2015). It is a predictor of mortality, the severity of the injury, and the need for ventilation (Hanekom et al. 2015). Inhalation injury, seen in 17% of thermal burn injuries, is mostly confined to the upper airway, and raises the risk of mortality by eight times in comparison to patients with burn injuries without inhalation injury, unless the burn covers less than 10% of the TBSA (Hettiaratchy and Dziewulski, 2004; Esselman, 2007; El-Helbawy and Ghareeb, 2011; Aung et al. 2018).

Leading up to the present day, mortality from external burn injuries has decreased markedly (Aung et al. 2018). This has not been seen in patients with inhalation injury (Aung et al. 2018). In a period of 12 years, it was noted that burn shock was the primary cause of mortality, while lung injury within the first week of injury was the second leading cause of mortality (Nielson et al. 2017). Together with other systemic responses, a complex inflammatory response is triggered in those patients who have been subjected to smoke inhalation (El-Helbawy and Ghareeb, 2011; Aung et al. 2018). The Abbreviated Injury Scale is largely used to grade inhalation injury, thus noting that a higher score is associated with microbial contamination, larger systemic cytokine release, and diminished gaseous exchange (Aung et al. 2018).

Inhalation injury can be subdivided into three groups; none/mild injury, moderate injury and severe injury (Hanekom et al. 2015; Aung et al. 2018). It also includes three zones, the upper airway, the lower airway, as well as the lung parenchyma, all of which can be assessed via a bronchoscope (Hanekom et al. 2015; Aung et al. 2018).

Thermal injury is associated with an injury to the upper airway on account of a reflex glottis closure (Hanekom et al. 2015). In such cases, the conductivity of dry air is poor, and the dissipation of the heat from the smoke-filled air is rapid (Hanekom et al. 2015). Injury to the lower respiratory airway is generally affected by the inhalation of steam or toxic chemicals, that are released from fires, and which affects the epithelial layer, thus causing sloughing, oedema and ultimately an obstruction of the airway (Hanekom et al. 2015).

Systemic toxicity results from the inhalation of toxic gases causing cellular dysfunction (Hanekom et al. 2015). Carbon monoxide (a by-product of combustion) reduces the amount of oxygen delivered to the tissues as it has a greater affinity to haemoglobin. Under such conditions, mitochondrial function also becomes inhibited (Hanekom et al. 2015). Should a patient be found unconscious and in an enclosed space, carbon monoxide poisoning should be suspected (Hanekom et al. 2015). Another gas produced through the combustion of certain materials (plastic, wool, silk, etc.) is cyanide gas (Hanekom et al. 2015). Cyanide affects the metabolism at a cellular level, causing anaerobic metabolism and thus the production of lactic acid (Hanekom et al. 2015). Patients with continuous lactic acidosis, even after fluid resuscitation, should be suspected of being victims of cyanide poisoning (Hanekom et al. 2015).

The increased severity of an inhalation injury in a patient is associated with an increased risk of acute respiratory distress syndrome, respiratory failure, a lower PaO_2/FiO_2 ratio, increased mortality, increased time on mechanical venilation, as well as an increased ICU LOS, and an increased need for the insertion of a tracheotomy (El-Helbawy and Ghareeb, 2011; Afshar et al. 2017; Sutton et al. 2017; Aung et al. 2018). An inhalation injury also causes damage to the mucocilliary escalator, mucous hyper-secretion (contributing to obstruction of the airway), airway oedema (causing occlusion, pulmonary oedema, pulmonary infection, and atelectasis owing to damage to the Type II pneumocytes, a ventilation/perfusion mismatch, decreased lung compliance, hypercarbia, and hypoxia (Hanekom et al. 2015; Nielson et al. 2017). The clinical status of patients with an inhalation injury should be assessed continuously as Aung et al. (2018) found that after 24 hours, the degree of inhalation injury can worsen; furthermore, within the first two days of injury, oxygen-free radicals, as well as inflammatory mediators, then promote the development of pulmonary oedema; while pneumonia may develop from four days to four weeks after an inhalation injury (Hanekom et al. 2015).

Patients with inhalation injury are prone to develop ventilator-acquired pneumonia within the first 48 hours from the initiation of the mechanical ventilation process (Choi and Jones, 2005; Hanekom et al. 2015). The extent of inhalation injury correlates to the duration of the exposure and the gases aspirated (Hanekom et al. 2015).

2.2.2 Chemical Injury

Injury relating to the work environment (industrial), the home (chemical substances), assault, or attempted suicide, usually occurs as a result of chemical burns and accounts for three percent (3%) of all burns cases (55% needing surgery) and leads to a 30% chance of mortality (Hettiaratchy and Dziewulski, 2004; Palao et al. 2009; Hanekom et al. 2015). The reason for a chemical burn is largely associated with the body parts burned; whereas assault and attempted suicide generally incorporate the trunk, head and neck, and injuries relating to work predominantly involve the extremities (Hanekom et al. 2015). The injury inflicted on the bodily tissues involves a wide variety of reactions, which are corrosive (Hettiaratchy and Dziewulski, 2004; Palao et al. 2009; Hanekom et al. 2015). They include a disturbance of the pH level, the metabolic processes and cellular membrane activity, as well as eschar, ulceration, necrosis and blisters (Hettiaratchy and Dziewulski, 2004; Palao et al. 2009; Hanekom et al. 2015).

There are many chemical substances that cause bodily tissue burns. Alkalotic substances cause liquefactive necrosis, whereas acidic substances cause the coagulation of the tissue (Palao et al. 2009; Hanekom et al. 2015). Some chemicals that are absorbed systemically are deadly. The many complications related to chemical burns include blindness, sepsis, renal failure, respiratory failure, axillary contractures, as well as hypertrophic scarring, leading to an extended hospital LOS (Palao et al. 2009; Hanekom et al. 2015). Once again, the severity of the injury is due to the time of contact with the chemical, the amount of the chemical that the patient is exposed to, and the nature of the chemical compound (Palao et al. 2009; Hanekom et al. 2015). Palao et al. (2009) reported that the exposure to the chemical may still be ongoing in the emergency room, thus causing a larger insult to the patient’s body.

2.2.3 Electrical Injury

Another type of burn relating to a person's occupation is an electrical burn that occurs predominantly in construction workers and electricians, and in children playing at home (Hanekom et al. 2015). Possibly, the main source of electrical burns in South Africa, is the theft of electrical cables which prevails beyond that of the epidemiology of international electrical burns (Padilha, Muganza and Candy, 2016). The relative frequency of this affliction in South Africa could be attributed to the severity of the injury, as well as to the limited availability of resources to treat the problem (Padilha, Muganza and Candy, 2016).
A patient who has sustained an electrical burn has a survival rate of a mere 42% (Hanekom et al. 2015). The different classifications of an electrical burn include an electrical arc/flash, which is at a high voltage but with no current passing through the body; a lightning strike, which is also at a high voltage; and a contact injury, each of which resulting in different levels of conductivity which pass through the bodily tissues as a thermal injury (Hettiaratchy and Dziewulski, 2004; Hanekom et al. 2015; Padilha, Muganza and Candy, 2016). In this type of injury, there are points of entry and exit causing damage to the tissue along the pathway between them (Hettiaratchy and Dziewulski, 2004).

Patients with electrical burn injuries should be observed for cardiac arrhythmias, especially if there was a loss of consciousness, and tissue oedema, leading to compartment syndrome (Hettiaratchy and Dziewulski, 2004; Hanekom et al. 2015). A lightning strike, though of short duration, may lead to cardiac arrest by causing instabilities in terms of the electrical conduction (Hanekom et al. 2015). A non-permanent injury owing to lightning/electrical burns includes a feathering shape on the skin known as the Lichtenberg feature (Hanekom et al. 2015). Although an electrical injury may present with skin burns, it may not be accompanied by major internal injuries (Hettiaratchy and Dziewulski, 2004; Hanekom et al. 2015). Conversely, though, there might be no skin burns but major internal injuries, with the severity of the injury dependent on the magnitude and type of current, its pathway, duration and the resistance of the bodily tissue (the higher the water content, the lower the resistance to the current) (Hettiaratchy and Dziewulski, 2004; Hanekom et al. 2015).

2.3 DEPTH OF TISSUE INJURY

The severity of burn injuries is classified by three distinct categories, namely superficial thickness, partial thickness and lastly, full thickness burns. The depth of the burn is important to identify in order to serve as a guideline to patient treatment, as well as to determine the morbidity of the patient (Devgan, 2006). A superficial burn (first-degree burns) is a burn injury to the epidermis which blanch with pressure, are red, painful and dry, do not blister and may need little to no medical intervention and no surgical intervention (e.g. sunburn) (Devgan, 2006; Cleland and Spinks, 2010; Hanekom et al. 2015; Mayo Clinic, 2015). Superficial burns do not scar, thus allowing healing to occur within six days after the injured skin has peeled away, leaving a new epidermis which has healed (Devgan, 2006; Hanekom et al. 2015).

Partial thickness burns could be superficial or deep (Cleland and Spinks, 2010; Hanekom et al. 2015; Mayo Clinic, 2015; Biggers, 2018). These are burns that destroy the protective layer of the skin as they reach below the epidermis to the dermis which accommodates the hair follicles, blood vessels and nerves (Cleland and Spinks, 2010; Hanekom et al. 2015; Mayo Clinic, 2015; Biggers, 2018). When superficial partial thickness burns are sustained, the basal layer of the skin is partially destroyed (Altintas et al., 2009; Kasten, Makley and Kagan, 2011; Hanekom et al. 2015). They are red and painful, and within a day, blisters form between the dermis and epidermis, with blanching occurring when pressure is applied (Altintas et al. 2009; Kasten, Makley and Kagan, 2011; Hanekom et al. 2015). A burn injury which is initially regarded as superficial may change to a partial thickness burn within 12 to 24 hours post-injury (Devgan, 2006; Hanekom et al. 2015). Healing can occur between seven and 21 days, via re-epithelialisation. The skin pigment may change but scarring is seen to be infrequent. However, if exudate and necrotic particles form on the wound surface, an infection may occur which would delay the healing process (Devgan, 2006; Monstrey, 2008; Hanekom et al. 2015). Early intervention could stunt the worsening of a burn wound (Devgan, 2006; Monstrey, 2008; Hanekom et al. 2015). Scarring is very likely to form in a partial thickness burn if healing takes more than three weeks and is less likely in the case of healing within two weeks (Devgan, 2006; Monstrey, 2008).

A deep partial thickness burn includes the complete basal layer of the skin and the deeper dermis, thus damaging the blood vessels, nerves, hair follicles and the glandular cells (Altintas et al. 2009; Kasten, Makley and Kagan, 2011; Hanekom et al. 2015). This burn is only painful when pressure is applied; it occurs without any blanching; blisters form and the area of injury is waxy, dry or wet, and with a mottled colour (Kasten, Makley and Kagan, 2011; Hanekom et al. 2015). Provided that no infection occurs, these burns heal within three to nine weeks without the need for grafting (Hanekom et al. 2015). A deep partial thickness burn could cause contractures or hypertrophic scarring (Devgan, 2006; Hanekom et al. 2015; Mayo Clinic, 2015). It has been seen that even with aggressive physiotherapy, joint problems are anticipated with deep partial thickness burns to the joint (Hanekom et al. 2015). The functional and aesthetic outcomes of a deep partial thickness burn where healing has taken longer than three weeks, are those of a full thickness burn (Hanekom et al. 2015).

Full thickness burns extend all the way to the subcutaneous tissue and may include the bones, muscles and fascia, and are unable to re-epithelialise (Cleland and Spinks, 2010; Giaquinto-Cilliers, 2014; Hanekom et al. 2015; Mayo Clinic, 2015). If the burn is circumferential, eschar forms, along with the occurrence of oedema, with increased pressure causing compression to the neural and vascular structures, which reduces the integrity of the areas below the eschar band (Hanekom et al. 2015). The area affected may have no or only decreased sensation; the skin may be waxy and white, grey and leathery, or black and charred; and with applied pressure, the dry, taut skin does not blanch (Hanekom et al. 2015). Blisters do not develop in full thickness burns (Hanekom et al. 2015). As a deep burn heals, the eschar is separated from the granulation tissue, which heals through the development of contractures and scarring and without any surgery, renders healing impossible (Devgan, 2006; Monstrey, 2008; Giaquinto-Cilliers, 2014; Hanekom et al. 2015; Mayo Clinic, 2015). Therefore, there is a need for debridement and grafting (surgery) for the reduction of the risk of hypertrophic scarring or contractures (Devgan, 2006; Monstrey, 2008; Giaquinto-Cilliers, 2014; Hanekom et al. 2015; Mayo Clinic, 2015). Contractures generally form in the popliteal fossa, the hip flexor surfaces, the cubital fossa, the axilla, the hand flexor surfaces, the finger and toe web spaces, and the neck (Schneider et al. 2006; Hanekom et al. 2015). Full thickness burns could cause functional impairments and would be the most likely to contract infections (Hanekom et al. 2015; Mayo Clinic, 2015). The distinctive differentiating factor between full thickness and deep partial thickness burns is the eschar formation, which makes the precise classification of the wound depth difficult and contributes to the development of complications of a local and systemic nature (Rosenberg et al. 2013).

2.4 LOCAL AND SYSTEMIC BODILY RESPONSES TO BURN INJURY

The local response of the body to injury can be divided into three zones:

- the zone of coagulation;
- the zone of stasis; and
- the zone of hyperaemia (Devgan, 2006; Hettiaratchy and Dziewulski, 2004; Orgill, 2009; Nielson et al. 2017; Strudwick and Cowin, 2018).

The zone of coagulation refers to the region of the greatest injury with protein coagulation and thus permanent tissue damage during the time of the injury (necrosis or eschar formation) (Devgan, 2006; Hettiaratchy and Dziewulski, 2004; Orgill, 2009; Nielson et al. 2017; Strudwick and Cowin, 2018).

The zone of stasis refers to the area of reduced tissue perfusion surrounding the zone of coagulation and where the tissue can be saved (Devgan, 2006; Hettiaratchy and

Dziewulski, 2004; Devgan, 2006; Orgill, 2009; Nielson et al. 2017; Strudwick and Cowin, 2018). Owing to the disturbance of the cellular membrane and leaks in the capillary membrane, it is associated with oedema (inflammation) (Devgan, 2006; Hettiaratchy and Dziewulski, 2004; Devgan, 2006; Orgill, 2009; Nielson et al. 2017; Strudwick and Cowin, 2018).

Lastly, the zone of hyperaemia (zone three) has undamaged microvasculature and an improved tissue perfusion, and is likely to recover despite the prevailing oedema (Hettiaratchy and Dziewulski, 2004; Devgan, 2006; Orgill, 2009; Nielson et al. 2017; Strudwick and Cowin, 2018). The wound may deepen and lose the area of stasis, which will increase the area of coagulation and thus result in the loss of more bodily tissue (Hettiaratchy and Dziewulski, 2004; Devgan, 2006; Orgill, 2009; Nielson et al. 2017). This is usually due to sepsis, an inflammatory response, oxidative damage, oedema and shock (thus increasing poor perfusion) and is likely to happen over a period of 48 to 72 hours even though the burn initially presented as superficial (Hettiaratchy and Dziewulski, 2004; Devgan, 2006; Orgill, 2009; Nielson et al. 2017).

A burn wound elicits a systemic response which is related to the presence of co-morbidities, the patient’s age, the location of the burn, the percentage of TBSA involved, the injury depth and any prevailing lung injuries, and might even cause patient mortality (Giaquinto-Cilliers, 2014). In a burn that extends over a total body surface area equivalent to or above 30%, inflammatory mediators are released and cause a systemic effect (Hettiaratchy and Dziewulski, 2004). These changes include cardiovascular problems (permeability of the capillaries, splanchnic and peripheral vasoconstriction, decreased myocardial contractility, systemic hypotension, and end-organ hypoperfusion), metabolic problems (a three-fold increase in the metabolic rate, decreased gut integrity, hypercatabolism, decreased endocrinal function, inflammation), respiratory problems (adult respiratory distress syndrome, bronchoconstriction), immunological problems (limited immune response) and systemic changes (Hettiaratchy and Dziewulski, 2004; Orgill, 2009; Corner et al. 2015). Cardiovascular complications that arise post-injury may affect the stability (heart rate, cardiac rhythm, systemic blood pressure and respiratory rate) of a patient that is critically ill. These in a patient’s level of stability will impact their ability to participate in rehabilitation sessions and limit their exercise capacity.

2.5 MANAGEMENT OF PATIENTS WITH MAJOR BURN INJURY USING ADVANCED TRAUMA LIFE SUPPORT

The patients admitted to hospital with burn injury are managed according to the principles of resuscitation outlined by ATLS. These include a primary and secondary survey to identify any life-threatening injuries sustained and the management that is appropriate for such injuries (Hanekom et al. 2015).

2.5.1 Primary Survey of ATLS

A primary survey is conducted in order to reduce the patient's risk of mortality (Giaquinto-Cilliers, 2014). According to ATLS, it is important in the primary survey to assess the following:

- airway and breathing (check ventilation and thoracic injuries after exposing the chest),
- circulation (control the haemorrhage, assess the heart rate and blood pressure, gain access intravenously, check capillary refill and circumferential burns),
- disability (check the body for fractures, abdominal injuries, deformities),
- neurological disability (the Glasgow coma scale),
- the exposure of the patient and his/her exposure to the environment (remove clothes and personal effects, logroll to assess, the TBSA, prevent hypothermia) and
- the patient's fluid resuscitation needs.

(Manifold and Armstrong, 2010; Hettiaratchy and Papini, 2004; Alharbi, et al., 2012; Giaquinto-Cilliers, 2014; Hanekom et al. 2015).

Early intubation is indicated where the patient has a suspected inhalation injury or occlusion of the upper airway owing to the rapid development of inflammation/oedema which could occlude the upper airway (Giaquinto-Cilliers, 2014; Hanekom et al. 2015).

2.5.1.1 Establishing the total body surface area of a patient who has sustained a burn injury

To calculate the body surface area affected by the injury, the Rule of Nines is largely used (Orgill, 2009). This tool indicates the area of the total body surface that has been burned and uses specific predetermined percentages for various parts of the body (Appendix A) (Orgill, 2009; Biggers, 2018; Wedro, 2019). The use of the Rule of Nines, constituting some of the criteria for hospital admission, helps to determine the level/form of patient management and the fluid resuscitation requirements of the patient (Biggers, 2018; Wedro, 2019). Burns that occupy 20 to 25% of the total body surface area or more need the extensive administration of intravenous fluids (Biggers, 2018).

Patients requiring specialised care include those with burns of 10% or more, those with burns to their major joints, feet, genitalia and hands, and those with electrical burns, chemical burns, and full thickness burns (Bigger, 2018).

2.5.2 Secondary Survey of ATLS

Directly following the primary survey, and once the patient has been stabilised, the next steps include the following:

- obtaining a thorough medical history and burn injury history (mechanism, location and time of injury),
- the administration of analgesia,
- the insertion of a nasogastric tube and urinary catheter,
- the running of several tests (a full blood count, tests for electrolyte levels, carboxyhaemoglobin levels, cardiac and muscle enzyme levels (in electrical burns), and a screening for toxins);
- the monitoring of vital signs.
  (Kasten, Makley and Kagan, 2011; Giaquinto-Cilliers, 2014).

Routine checks, with regard to a head-to-toe assessment, include the following:

- an assessment as to the presence of an infection,
- a diagnosis of compartment syndrome,
- a re-evaluation of the depth and percentage of burns involved in the TBSA,
- neurological, physical and radiological investigations
- an electrocardiogram examination (in the case of an electrical injury)
  (Manifold and Armstrong, 2010; Alharbi, et al., 2012; Giaquinto-Cilliers, 2014; Hanekom et al. 2015).

2.5.3 Definitive Care as Part of ATLS

Once the primary and secondary surveys have been completed, definitive care is commenced (Hanekom et al., 2015). This involves patient transfer from the emergency unit to theatre, to the Burns ICU, or to the ward, depending on his/her individual needs. Definitive care includes the first 24 hours of care, pain management, wound management and surgery (Hanekom et al., 2015). The requirements for any fluid replacement should be calculated and administered in order to maintain haemodynamic stability (Hanekom et al., 2015).

After a major burn injury (>20% TBSA burns), and within the first 24-hour period, the patient might sustain burn shock, which is a systemic inflammatory response, thus increasing the vascular permeability at the burn site and causing the movement of fluid into the interstitium (interstitial oedema) (Giaquinto-Cilliers, 2014; Hanekom et al. 2015). At this point, the patient requires intravenous fluid resuscitation; however, an excess of fluid is a concern as it increases oedema and may cause pulmonary oedema (Giaquinto-Cilliers, 2014). The fluid administered to the patient should be monitored in terms of urinary output, as well as heart rate (Giaquinto-Cilliers, 2014).

It is important to monitor and administer the increase in calorie intake through the enteral feeding tubes with regard to the hypermetabolic state that results from burns (Hanekom et al. 2015). As mentioned above, routine tests (laboratory and scans) should be conducted. They would include reassessing the wounds after washing, assessing the need for intubation and the need for surgery (e.g. escharotomy) (Hanekom et al. 2015).

It is important that the multi-disciplinary team should evaluate and re-evaluate the patient throughout his/her period of care, with set goals and outcome measures in place, thus maintaining and achieving the desired functional and medical outcomes (Manifold and Armstrong, 2010; Orgill, 2009; Hanekom et al. 2015). The patient should be assessed functionally on discharge from the ICU to the ward and again on hospital discharge (Hanekom et al. 2015). The education of the patient and the family should be on-going to promote healing and effective functional performance (Hanekom et al. 2015).

2.6 OBJECTIVE OUTCOME MEASURES

2.6.1 Rule of Nines (Appendix A)

As mentioned previously, the Rule of Nines is an outcome measure, largely used in trauma and medicine, to evaluate the area of body surface that is wounded by a burn injury in adults (Orgill, 2009; Wedro, 2019; Moore et al. 2020). Biggers (2018) and Moore et al. (2020) state that the Rule of Nines is predominantly used in patients with partial thickness and full thickness burns. This is a hasty and valuable technique in determining the extent of a burn injury in adult patients (Orgill, 2009; Biggers, 2018). Moore et al. (2020) and Wedro (2019) state that the Rule of Nines aids in the estimation of the fluid resuscitation needs of the patient and guides the decision to transfer a patient to a Burns unit. No literature regarding the reliability and validity of the Rule of Nines is available. This outcome measure is widely used in the burn population as well as used at the hospital this study was conducted and was thus selected to be used in this study.

2.6.2 Injury Severity Score

Since its inception, the injury severity score (ISS) has been used more prominently than other similar outcome measures (Palmer, 2007). It is an anatomical injury index working with the abbreviated injury scale which approximates the severity of the injury (Wong and Leung, 2008). The ISS uses the three most injured anatomical areas as derived from the abbreviated injury scale (Wong and Leung, 2008; Karadsheh and Taylor, 2018). The anatomical regions include the face, head and neck, chest (thorax), abdominal contents, pelvic contents, spine, upper limbs, lower limbs, as well as external and additional traumatic injuries (including abrasions, contusions, cuts) (Karadsheh and Taylor, 2018).

The abbreviated injury scale is calculated as follows: 0 – no injury, 1 – minor injury, 2 – moderate injury, 3 – serious injury (not life threatening), 4 – severe injury (life threatening but the probability of survival), 5 – critical injury (life threatening, uncertain survival), 6 – maximal injury (possibly fatal) (Karadsheh and Taylor, 2018). Thus, the ISS score is equal to the three anatomical regions, most injured, squared and added together, with a score ranging from 1 (minimum) and 75 (maximum) (Karadsheh and Taylor, 2018). However, any one abbreviated injury scale score of 6, brings the total score to its maximum of 75 (Karadsheh and Taylor, 2018). This score should be repeated throughout patient care and compared to its baseline and subsequent scores (Palmer, 2007). An ISS of 15 or more is regarded as a major traumatic injury with mortality predicted to be at a rate of 10% or higher (Palmer, 2007; Karadsheh and Taylor, 2018). Not only can the ISS be useful in predicting mortality; it can also help determine the expected ICU LOS, the hospital LOS, the duration of the disability, the discharge destination, the cost of the hospital stay, and the need for major surgery (Palmer, 2007). The interobserver reliability for the ISS and AIS may be insufficient in providing good data specifically when performed by sole coders that have variable degrees of motivation, experience and training (Maduz et al. 2017). Maduz et al. (2017) tested the reliability on severely injured trauma patients, where medical patients without trauma were excluded. Ringdal et al. (2013) found an inter-rater variability in a trauma population and could not identify values in the level of agreement which is deemed acceptable (+/- 9 units of disagreement). There is scarce research in the burns sector which validates the use of the ISS. Cassidy et al. (2014) found the ISS to be a poor mortality predictor in a patient with major burn injuries and the Burns ISS should rather be used. The ISS, however, was used as an outcome measure in this study as it was one of the outcome measures used at the hospital where this study was conducted.

2.6.3 **Revised Baux Score (Appendix B)**

The prediction of mortality will aid triage, help provide a prognosis, and act as a guideline for treatment (Dahal et al. 2015). The three main predictors of mortality in a patient with burn injuries include their age, the TBSA involved and the presence of an inhalation injury (Knowlin, 2017). The original Baux score determines the likelihood of mortality by outlining the importance of the association of the age in a patient with an acute burn injury and the TBSA burned (Karimi et al. 2013). Thereby, it includes the summation of the percentage of the total body surface area of the patient that was burned, including the age of the patient, thus making it possible to estimate the risk of death percentage (Heng et al. 2015).

The original measure, the Baux score, was subsequently appraised by Osler et al. (2010), who added inhalation injury as part of the equation, the result being the revised Baux score. The revised Baux score is thus calculated by adding the percentage of the TBSA burned to the patient age; and by then adding the product of 17 multiplied by (1) - the presence of an inhalation injury or (0) – the absence thereof (Dokter et al. 2014; Dahal et al. 2015). Dokter et al. (2014) found the Baux score to accurately predict the mortality of patients with burn injuries, while Heng et al. (2015) noted that the revised Baux score is independently associated with the mortality of a patient when admitted to the ICU with burns above 15% of the TBSA of the patient.

Smith, Allorto and Clarke (2016) found that predicted mortality scores could be useful in resource-scarce countries, for instance, South Africa. The revised Baux score ranges from 1 to 134 (Smith, Allorto and Clarke, 2016). A 50% chance of mortality is true for those who score over 75, while a score of more than 100 suggests that the patient is destined for palliative care (Smith, Allorto and Clarke, 2016). The revised Baux score equation (Appendix B) is an externally valid measure with high sensitivity and specificity, as well as the most accurate and reliable outcome measurement tool for predicting mortality in those admitted to an ICU with acute major burn injuries (Karimi et al. 2013; Dokter et al. 2014; Woods, Quinlan and Shelley et al. 2015). Aside from the fact that the revised Baux score can be useful in a resource-scarce country such as South Africa, it is also seen to be a valid and reliable tool.

2.6.4 **FSS-ICU (Appendix C)**

Outcome measures are part of the standard management of patients by physiotherapists and aids in the documentation of the effectiveness of physiotherapy treatment provided to patien (Thrush et al. 2012). Over the years functional outcome measures have been developed, for the ICU population, to improve the assessment of patient function (Alves et al. 2019). Functional outcome measures, for example, the Functional Status Score for ICU (FSS-ICU) for the intensive care unit patients (Appendix C) were recently developed and are being used to estimate the functional ability of a critically-ill patient and to monitor his/her progression in function (Parry et al. 2015; Huang et al. 2016). The FSS-ICU has been recommended as a functional outcome measurement tool in an ICU setting (Parry et al. 2015). Thrush et al. (2012) found this outcome measurement tool useful to monitor the functional progressions of patients in a hospital for longer term acute care. This test takes 10 to 30 minutes to execute, and uses a seven-point scoring system (Parry et al. 2015; Huang et al. 2016). Higher scores represent improved function in terms of the scale ranging from 0 to 35 (Parry et al. 2015; Huang et al. 2016).

The FSS-ICU is a good predictor with regard to ICU LOS, hospital LOS and effectively discriminates between discharge destinations of patients (Thrush et al. 2012; Parry et al. 2015; Huang et al. 2016; Wu, 2018). It is receptive to change in function over a period of time, and presents high validity (concurrent, convergent and discriminant validity – construct validity; criterion validity – the extent of the measure relating to its outcome; predictive validity; as well as known group validity – the ability to discriminate between differing groups) (Parry et al. 2015; Huang et al. 2016). A high internal consistency level was also noted in ICU patient populations with small floor/ceiling effects at awakening and ICU discharge (Parry et al. 2015; Huang et al. 2016). Alves et al. (2019), found intrarater (homogenous scoring) and interrater (consistent scoring) reliability, construct validity (measuring what it claims), adequate internal consistency (correlation between items on the test) and ceiling affects. Gonzalez-Seguel et al. (2019) and Silva et al. (2017) were able to culturally adapt and translate the FSS-ICU to Chilean and Brazilian Portuguese languages, respectively, and found that the physiotherapists could easily understand the translated outcome measurement tool and apply it in an ICU setting. The FSS-ICU was chosen for this study due to its high validity, reliability and being able to note the functional progression of a patient over time.

2.7 SURGICAL BURN MANAGEMENT

Part of the management for the patient with major burn injury includes surgery. Surgery is typically indicated with deep partial thickness and full thickness burns, contaminated burns, full thickness circumferential burns and requires excision of the necrotic tissue to reduce the risk of mortality (Alharbi et al. 2012; Giaquinto-Cilliers, 2014). Treatments in conjunction with surgery include physiotherapy, splinting, the application of dressings, negative pressure wound therapy, and positioning (Hanekom et al. 2015).

Excision and grafting, when carried out early (i.e. within the first week) are reported for the reduction of the risk of inflammation, infection, sepsis, as well as multi-organ failure (Orgill, 2009). Excision and grafting promote the physiological closure of the wound in that they involve the removal of all of the necrotic and inflamed tissue until a stage is reached where the tissue present is viable (Orgill, 2009; Giaquinto-Cilliers, 2014).

2.7.1 Escharotomy

Eschar is formed from deep burns, which can be circumferential in nature and is constricting to the affected limb (Giaquinto-Cilliers, 2014; Hanekom et al. 2015). Eschar is dead and de-natured tissue; it is leathery, immovable and constrictive (Krieger, et al. 2005; Orgill, 2009; Hanekom et al. 2015). The eschar restricts circulation and thus compromises the limb below the eschar band, which can ultimately cause burn-induced compartment syndrome or could even cause restrictions to the abdominal wall and chest, thus impairing ventilation and chest expansion (Tiwari, 2012; Giaquinto-Cilliers, 2014; Hanekom et al. 2015). As such, it needs to be cut out to prevent further injury (Tiwari, 2012; Giaquinto-Cilliers, 2014; Hanekom et al. 2015). This involves decompression techniques, namely escharotomy and fasciotomy (Orgill and Piccolo, 2009). An escharotomy, which is typically conducted in a surgical emergency, is carried out within hours of admission to release eschar and to prevent tissue necrosis or the loss of a limb (Orgill and Piccolo, 2009; Tiwari, 2012; Giaquinto-Cilliers, 2014; Hanekom et al. 2015). It is done via one or multiple longitudinal incisions of healthy tissue through to the eschar, thus exposing the underlying fat, and eventually results in healthy tissue (Orgill and Piccolo, 2009; Tiwari, 2012; Giaquinto-Cilliers, 2014; Hanekom et al. 2015). As mentioned, eschar is constrictive (Hanekom et al. 2015). As such, after an escharotomy, the cut tends to broaden proportionally to the pressure within the tissue (Hanekom et al. 2015). Skin closure may be necessary (Hanekom et al. 2015). This is achieved through a skin graft, which serves as a means to managing the wound as it heals over time (Hanekom et al. 2015). A non-surgical escharotomy or an enzymatic debridement is effective and has fewer long-term complications and fatal outcomes as opposed to those of a surgical escharotomy, which could cause blood loss, damage to important structures, the increased risk of sepsis and might prove to be very painful, thus often requiring patient sedation or anaesthesia (Krieger et al. 2005).

2.7.2 Fasciotomy

Fasciotomy is undertaken when there is a suspicion of compartment syndrome and to release the fascia (Ritenour et al. 2008; Giaquinto-Cilliers, 2014; Hanekom et al. 2015). (This is usually the case with circumferential burns.) (Ritenour et al. 2008; Giaquinto-Cilliers, 2014; Hanekom et al. 2015). The surgeon makes an incision in the skin and extends the excision to the deep fascia to relieve the pressure in the compartments in order to save the limb and/or life of the patient (Tiwari, 2012; Hanekom et al. 2015). Once this has been done, elevation is important as it reduces swelling and allows for skin grafting (Hanekom et al. 2015). Limb movement and splinting of the limb are continued to maintain active and passive joint range and muscle length (Hanekom et al. 2015). Once the swelling has decreased, the surgical site of the fasciotomy might need skin grafting, as is the case with an escharotomy (Hanekom et al. 2015). An increased frequency of mortality was noted in patients who required a repeat fasciotomy, as well as in those who underwent delayed fasciotomies (Ritenour et al. 2008). In the latter case, increased rates of amputation were evident (Ritenour et al. 2008).

Amputation is common but is more prevalent in electrical burns (Spires et al. 2007). It is specifically necessary in patients requiring a fasciotomy or an escharotomy, and where the decompression failed, thus causing sepsis (life threatening) and widespread tissue necrosis, as well as compromising the neurovascular structure (Spires et al. 2007).

2.7.3 Wound Debridement

The debridement or excision of burn wounds within two to seven days after admission reduces the risk of mortality, sepsis and LOS, as well as reducing the bacterial infection risk, and presents a bed of tissue, which is viable for skin grafting or conservative management (Hanekom et al. 2015; Hirche et al. 2017). Debridement is one of the most necessary surgeries for a patient with burn injuries (Edmondson et al. 2018). Debridement is the cleaning and removal of contaminated and necrotic tissue in partial-thickness and full-thickness burns in that it removes the thin necrotic layers one at a time until a viable bleeding bed of tissue is attained to aid in healing and to minimise scarring (Rosenberg et al. 2013; Hanekom et al. 2015; Hirche et al. 2017; Edmondson et al. 2018). In the case of a full-thickness burn, a debridement and the closure, through a skin graft, within the first 48 hours of the burn incident, limits the inflammation associated with the injury (Gauglitz et al., 2018).

The decision regarding the correct debridement technique should start with the careful assessment of the patient and the wound (Moore, 2015). Important aspects in the decision making process are as follows: involve the patient in the process (patient's view), know the medical condition of the patient (may have contraindications to certain treatments), the healthcare professional should be competent and trained in the chosen debridement technique, the surrounding infrastructure and resources should be applicable to the patient and the debridement procedure chosen (Moore, 2015).

Debridement is not only a surgical procedure, as in the case of enzymatic debridement, involving dressings. It can also be known as an escharectomy or sloughectomy (Alharbi et al. 2012; Rosenberg et al. 2013). Different types of wound debridement can be performed including autolytic debridement, which involves the application of moist dressings in the form of hydrocolloids and hydrogels to the wounds in order to retain the fluids of the wound, and thus allow the body to independently clear itself of necrotic tissue (Giaquinto-Cilliers, 2014; Hanekom et al. 2015; Edmondson et al. 2018). Hydrocolloids and hydrogels are suitable for moist wounds and for superficial debridement, and patients who are unable to withstand a more aggressive debridement (e.g. patients with comorbidities or the elderly), and are not used on infected wounds (Giaquinto-Cilliers, 2014; Hanekom et al. 2015;

Edmondson et al. 2018). The moist form of debridement is not predictable and is slow (Giaquinto-Cilliers, 2014; Hanekom et al. 2015; Edmondson et al. 2018).

An enzymatic (chemical) debridement involves the use of chemicals to dissolve dead tissue, thereby preparing the wound for healing, as well as for grafting on an area of the body which is surgically difficult to debride (e.g. the hand) (Rosenberg et al. 2013; Giaquinto-Cilliers, 2014; Hanekom et al. 2015; Edmondson et al. 2018). On account of the softening and breaking down of the eschar, the risk of wound infection might be intensified (Rosenberg et al. 2013; Giaquinto-Cilliers, 2014; Hanekom et al. 2015; Edmondson et al. 2018). It has been found that enzymatic debridement is an effective procedure which aids in the reduction of loss of blood, reduces a skin grafting need and the amount of invasive debridement needed (Hirche et al. 2017).

Mechanical debridement involves an adjustable pressurised water device to rid the wound of any unwanted tissue, but is a painful technique (Giaquinto-Cilliers, 2014; Edmondson et al. 2018). Moore (2015) explains mechanical debridement with soaked gauze (specific to dead tissue removal once dried and gauze is removed), wet-to-dry mechanical debridement (adheres to necrotic and viable tissue, and so removes both), impregnated gauze (much like wet-to-dry dressings) and monofilament fibre pad (removes slough, exudate and necrotic tissue). With exception to the monofilament fibre pad, mechanical debridement is very painful and may not be received well by the patients (Moore, 2015).

Moore (2015) stated one trial reported gauze soaked mechanical debridement with dextranomer cleaned the wound more effectively and another trial reported enzymatic debridement to be more effective and quicker. Moore (2015) found another study that reported the monofilament fibre pad is easy and safe to use and noted it to have a quicker debridement and wound dressing time, no damage was seen to the skin surrounding the wound bed, pain after dressing changes was reduced and there was an improved wound bed condition as well as an enhanced wound bed visual (Moore, 2015).

A glove-gauze regimen was given to patients with burns to their hands once silver sulfadiazine was applied over the burn (Vyrva, 2020). Vyrva et al. (2020) found that with self-directed passive and active ROM, majority (96%) of the patients were able to reach full ROM in their hands as well as full function without formal physiotherapy sessions.

Surgical debridement is an aggressive form of debridement executed with a scalpel or laser, or alternatively, a Vesajet, and may simultaneously include several areas of the body (Giaquinto-Cilliers, 2014; Hanekom et al. 2015; Edmondson et al. 2018). This is the preferred technique of debridement, particularly in deep burn wounds, sepsis and burn wounds on large flat surfaces (Yang et al. 2007; Hanekom et al. 2015). Numerous studies have reported that surgical debridement done early can reduce loss of blood, risk of infection and hospital LOS as well as improving survival (Yang et al. 2007). Its effectiveness can be owed to the fact that all the necrotic tissue should be removed in a surgical debridement procedure exposing a viable bed of tissue and reducing the need for any future revision debridement (Rennekampff et al. 2006). Debridement by laser is seen to decrease bleeding at the wound site during and after a procedure (Rennekampff et al. 2006). Versajet may be superior in terms of difficult to reach areas (e.g. face, hand, foot) where contouring would not be easy with other modalities for superficial to partial thickness burns (Rennekampff et al. 2006).

Another type of debridement is biological debridement, which uses sterile maggots to clear the wound of necrotic tissue (Hirche et al. 2017; Edmondson et al. 2018). It is highly effective but has not yet been accepted by patients and nursing staff (Hirche et al. 2017; Edmondson et al. 2018).

Repeat debridements are usually performed in wounds with an amplified risk of infection such as injuries caused by flammable liquid, chemicals, hot oil and electrical burns, for the burn wound to be suitably cleaned in order to encourage healing, and can be done every 24 or 36 hours, as indicated (Giaquinto-Cilliers, 2014; Hanekom et al. 2015). The recovery from blood loss owing to deep debridement usually takes up to 48 hours, and may cause a critically-ill patient to become even more unstable. The physiotherapist needs to alter the treatment with this in mind (Hanekom et al. 2015). The complications from a debridement consist of bleeding, infection, risking the removal of healthy tissue, heat, and lastly, pain (Rosenberg et al. 2013; Hanekom et al. 2015).

2.7.4 **Skin Grafts**

Skin has three chief purposes, namely for sensation, protection and thermo-regulation (Lucas, 2017). Skin grafting is an essential surgical procedure where healthy skin from one area is removed and placed on a different area of the body, which has sustained injury. Skin grafting is performed when the patient’s body has lost skin not only due to a burn injury, but also infection or surgery (Shimizu and Kishi, 2011; Stang and Hannan, 2017; Berman, Zieve and Conaway, 2018).

For any skin graft to take successfully, all of the necrotic tissue should be excised from the wound bed and the edges of the wound exposed (Giaquinto-Cilliers, 2014). Skin grafting not only protects the wound from infections but also reduces the metabolic demand and the loss of fluid, and on a larger scale, reduces the rate of mortality of burn victims (Orgill, 2009; Hanekom et al. 2015).

There are many grafting procedures, including the following:

- autografts - a split-thickness and full-thickness skin graft,
- cultured epithelial grafts - sheets of skin grown from a skin biopsy,
- dermal substitutes - with prosthetics being applied when allo- and xenografts are not available,
- allografts - temporary cadaveric substitutes,
- xenografts - temporary bovine or swine grafts, and
- artificial skin substitutes - temporary
  (Hanekom et al. 2015).

2.7.4.1 Split thickness skin graft

A split thickness skin graft is a graft that removes the epidermis and part of the dermis from a healthy donor site (Shimizu and Kishi, 2011; Stang and Hannan, 2017). It is a fragile graft that is used to cover a large area and which appears smooth (Stang and Hannan, 2017). This type of graft may have multiple holes cut into it that allow the skin to be stretched and to cover a larger surface area, thus requiring a smaller donor site and allowing for the fluid from under the graft to drain (Stang and Hannan, 2017). This is called a meshed skin graft (Shimizu and Kishi, 2011). Other split thickness skin grafts include the chip skin graft and the stamp skin graft and are classified, as such, according to their shape (Shimizu and Kishi, 2011).

2.7.4.2 Full thickness skin graft

A full thickness skin graft is a graft that includes all of the epidermis and dermis and is usually sourced from a smaller donor site that is subsequently closed and stitched up (Shimizu and Kishi, 2011; Stang and Hannan, 2017). A full thickness skin graft is better aesthetically than the split thickness skin graft as the graft heals well with the surrounding skin (Stang and Hannan, 2017).

After grafting on a viable bed of tissue that is rich in blood vessels, it is recommended that the patient rest for up to five days, with or without a splint (Orgill, 2009; Shimizu and Kishi, 2011; Hanekom et al. 2015). However, this needs to be reviewed by the doctor (Orgill, 2009; Shimizu and Kishi, 2011; Hanekom et al. 2015). For the skin graft to ‘take’ on the viable bed of tissue, blood vessels need to start forming and attaching to the surrounding skin (Stang and Hannan, 2017). This usually happens within 36 hours (Stang and Hannan, 2017).

If the graft site has not 'taken', it might be due to a number of causes, namely the accumulation of blood or fluid under the graft site, infection, or the excessive movement of the graft on the viable bed of tissue, which may lead to a second skin-grafting surgery (Stang and Hannan, 2017). Should the patient be a smoker, this would inevitably be a precursor to the failure of the skin graft to 'take' (Stang and Hannan, 2017). The reason being that smoking has been seen to significantly delay healing and lengthen recovery times, impair endothelial function, cause peripheral artery disease, poor oxygenation of the tissues (important for wound healing and infection prevention), wound dehiscence, scar formation (atypical), wound infection and adiponecrosis (Perez-Guisado et al. 2012; Cetiner et al. 2017; Ellis, 2018; Sakai et al. 2019). Other implications of smoking on wound healing include necrosis of the wound, anastomoses leakage, wound rupture, as well as affect the quality of healing (reduction in tensile strength) (Ellis, 2018). Delayed healing in smokers is also believed to be due to the chemicals in cigarette smoke, which reduce tissue oxygenation and cause inflammatory and proliferative disturbances (Ellis, 2018).

The healing of a graft site takes a little more than two weeks, which is also the approximate time taken for the donor site to heal (Stang and Hannan, 2017). Shimizu and Kishi (2011) noted that split thickness skin grafts can 'take' with fewer blood vessels but are prone to contractures, whereas full thickness skin grafts need more blood vessels and are less prone to contractures. It is important to note that a common complication of excision and grafting is bleeding, and measures should be taken to limit this (Orgill, 2009). Other complications include the risk of removing viable tissue, pain from the procedure, abnormal sensation, contracture formation, haematoma development, infection as well as skin graft rejection (Hanekom et al. 2015). Stretching or any other activities that may damage the graft site should be prohibited for a minimum of three to four weeks (Stang and Hannan, 2017).

2.7.5 Skin Flaps

In some instances, a skin graft cannot be used as in the case of exposed bones and_deep wounds (Shimizu and Kishi, 2011). The Surgeon then performs muscle flaps or skin flaps (Shimizu and Kishi, 2011). Skin flaps are more resilient than skin grafts as they have the blood supply already attached to the tissue, they are more aesthetically pleasing, and have the bulk needed to fill in concave defects (Lucas, 2017; Kita, 2019).

A skin flap incorporates healthy skin, as well as tissue and vasculature, and, like a skin graft, it is removed and placed on an injured area (Rednam et al. 2017; Berman, Zieve and Conaway, 2018). The survival of a skin flap is largely dependent on the vascularisation (the dermal and subdermal plexus) of the flap and the pressure of the perfusion (Lucas, 2017). A local skin flap involves the skin and fat, and may also involve the muscle, with the tissue usually still attached to the body either via its base or a blood vessel (Berman, Zieve and Conaway, 2018; Kita, 2019). A free flap is the removal of the skin flap from its original site, but with a blood vessel (artery), which is then surgically attached to the new site (Rednam et al. 2017; Berman, Zieve and Conaway, 2018; Kita, 2019).

The donor site could be located in a number of different areas of the body and is chosen on the basis of the similarity of its skin to that at the area of injury, the issue as to whether the scar at the donor site will be visible, and the proximity of the donor site to the site of the wound (Berman, Zieve and Conaway, 2018; Kita, 2019). It has been noted that once the skin flap has been executed, the donor site is more painful than the flap site (Berman, Zieve and Conaway, 2018). This is due to the open nerve endings at the donor site (Berman, Zieve and Conaway, 2018).

The complications arising from skin flap procedures include those associated with general surgical risks such as infection, bleeding, bruising, skin discolouration, vascular deficiency, partial and complete necrosis, clotting, pain, deformity, decreased sensation, and cardiac and pulmonary complications (Rednam et al. 2017; Kita, 2019). On account of insufficient vascularisation, the most common complication after skin-flap surgery is necrosis (Karimipour, 2017). Complications lead to more surgeries, a prolonged hospital stay and prolonged out-patient visits (Karimipour, 2017).

If the patient is not pleased with the aesthetics of the scars and surgical outcomes (e.g. the graft site), he/she will undergo reconstructive surgery (Orgill, 2009).

2.7.6 Wound Management:

Wound management can assume the form of applying wound dressings. These dressings depend on the site of the wound and the wound depth, and the extent of the burn, as well as on the cost and availability of treatment (Hanekom, et al. 2015). A form of wound management includes that of negative pressure wound therapy.

2.7.6.1 Negative pressure wound therapy:

Negative pressure wound therapy or 'vacuum dressing' is a more common term for this type of wound therapy (Hanekom et al. 2015). In wounds with large exudations, a piece of foam is measured and cut according to the dimensions of the injury and positioned in the wound (Gregor et al. 2008; Hanekom et al. 2015). A tube is positioned under the foam and attached to a vacuum pump (Hanekom et al. 2015). The wound site is sealed with a dressing that is transparent and perforated by the tube that in its turn is attached to a vacuum pump that produces a negative pressure to the wound site (Branwell and Musgrave, 2004; Gregor et al. 2008; Hanekom et al. 2015). Negative pressure wound therapy stimulates the growth of granulation tissue, keeps the wound bed clean, increases dermal perfusion, removes exudates, and reduces oedema (Branwell and Musgrave, 2004; Gregor et al. 2008; Hanekom et al. 2015). Negative pressure wound therapy may be a precursor to skin grafting and may be used subsequent to debridement, and also after skin grafting, provided that there is a non-adhesive dressing between the foam and the skin graft to protect the graft when the foam is removed (Hanekom et al. 2015). Patient mobility can continue with negative pressure wound therapy, on condition that the foam and dressing remain intact (Hanekom et al. 2015). This is achieved by clamping the tube (Hanekom et al. 2015). Antimicrobial dressings and temporary skin substitutes are used after debridement in order to avoid infection and may also be necessary right up to the stage where split skin grafting or autografting is performed (Giaquinto-Cilliers, 2014).

2.7.7 Tracheostomy

If a patient is due for a prolonged stay of more than 10 to 14 days, in ICU, and would be on mechanical ventilation, a tracheostomy is indicated (Durbin, 2010; Hanekom et al. 2015). On the condition that it would be performed at an early stage, it would reduce the likelihood of mortality (Durbin, 2010; Hanekom et al. 2015). A tracheostomy is performed by creating a stoma in the neck and placing an artificial airway through the stoma to the trachea (Hanekom et al. 2015). Of late, the most common method used for a tracheostomy is percutaneous dilatation, which is minimally invasive, and which is performed under the guidance of a bronchoscopy. Alternatively, a tracheostomy is performed surgically (Durbin, 2010; Depetris et al. 2015; Hanekom et al. 2015). Tracheostomies are common in patients with burn injuries, particularly in patients that have a TBSA burn involvement greater than 60%, and patients who have had recurrent surgeries and burns to the neck and head (Aggarwal, Smailes and Dziewulski, 2009; Depetris et al. 2015).

Other indications to perform a tracheostomy include extended respiratory failure, failure for the patient to be weaned from mechanical ventilation, limited protective airway reflexes, decreased consciousness, vast changes in physiology associated with medical illness or injury, and an obstruction in the upper airway (Durbin, 2010; Cho, 2012). Furthermore, a tracheostomy prevents upper airway and laryngeal harm, as well as swelling and compression, and in this way protects the airway (Durbin, 2010; Cho, 2012). It improves oxygenation, and facilitates greater ease in performing secretion suctioning (Durbin, 2010; Cho, 2012). A tracheostomy enhances the comfort and safety of the patient, decreases the necessity for sedation, lessens the dead space ventilation and airflow resistance to aid the weaning of the patient off the ventilator, more effective oral cleaning, and allows for a timely ability for the patient to speak, and a shorter hospital LOS (Durbin, 2010; Hanekom et al. 2015).

The complications related to a tracheostomy include bleeding, obstruction of the tube, the development of a pneumothorax, infection, as well as accidental decannulation. Subsequent complications include pneumonia, problems with aspiration, tracheomalacia, the formation of granulation tissue (tracheal stenosis) and the development of a trachea-oesophageal fistula (Epstein, 2005). Complications in a patient with major burn injuries who undergoes a prolonged tracheostomy include increased risk of laryngotracheal pathology, dysphagia and dysphonia, and patients usually take longer to start their intake orally and attain a pre-injury diet (Clayton, Kennedy and Maitz, 2010). Patients with burn injuries and with a tracheostomy have a higher rate of infections of the chest, which may be accounted for by inhalation injury, prolonged mechanical ventilation and a larger TBSA involvement (Aggarwal, Smailes and Dziewulski, 2009). Care for the tracheostomy is the responsibility of the multidisciplinary team and should be prioritised as poor care of the tracheostomy directly affects the patient's risk of mortality (Hanekom et al. 2015). As a physiotherapist, if the patient is presenting with signs of respiratory distress, decreased saturation, decreased heart rate, decreased respiratory rate and/or the patient is able to speak (inflated cuff), the therapist should notify the appropriate members of the multidisciplinary team for assistance (McGrath et al. 2012; Hanekom et al. 2015b). When suctioning the patient, in the instance that the suction catheter cannot pass through the tracheostomy tube, again, the appropriate members of the multidisciplinary team should be notified immediately (McGrath et al. 2012; Hanekom et al. 2015b). Physiotherapists are responsible for the education of the patient, family and nursing staff, the supervision of the cuff pressure, tube patency and cleaning of the tracheostomy, as well as humidification, secretion clearance, weaning and the decannulation of a tracheostomy tube (Parker et al. 2010; McGrath et al. 2012; Hanekom et al. 2015b; Bonvento et al. 2017).

2.8 BURN INJURY COMPLICATIONS

There are several complications that can arise as a consequence of major burn injury which may delay recovery of a patient. A burn injury of more than 20% TBSA affects the bodily functions within the first 24 hours of injury (Hanekom et al. 2015).

2.8.1 Infection

Seventy-five percent (75%) of patients with a burn injury involving over 40% of the TBSA are at risk of death from sepsis on account of infection of the burn wound and/or inhalation injury, as well as from other complications resulting from infection (Church et al. 2006). The immune system of a patient with major burns is suppressed and thus an infection can arise from anywhere in the body and could present complications to its effective management. An injury that is of a thermal nature, causes the body to regress into a condition of immunosuppression, thus increasing the patient's vulnerability to sepsis as well as multiple organ failure (Nielson et al. 2017). The burn injury surface area may accumulate necrotic debris and fibrinous exudates, which could allow for bacterial growth and a delay in wound healing (Orgill, 2009; Hanekom et al. 2015). Patients with major burn injuries are likely to contract a localised or systemic infection, which affects healing and may be resistant to antibiotics, thus making the infection difficult to treat (Orgill, 2009). A major burn injury causes inflammation, muscle atrophy, insulin resistance and increased metabolism (Nielson et al. 2017). A burn injury increases the metabolic rate three-fold and may last at this rate for several years subsequent to the closure of the burn wound and long after healing has been achieved (Hettiaratchy and Dziewulski, 2004; Hanekom et al. 2015; Greenhalgh, 2017; Nielson et al. 2017).

In order to prevent and manage the onset of infection, infection control practices should be adhered to (Church et al. 2006). This is also imperative in wound care, including cleaning of the wound as well as the excision of eschar (Church et al. 2006). The use of silver impregnated devices, such as dressings and topical antibiotics, nutritional support, prophylactic antibiotics (systemic), the administration of human tetanus immunoglobulin and topical antibiotics, are other essential practices (Church et al. 2006).

2.8.2 Malnutrition

In the Eastern Cape (South Africa), malnutrition was noted in 46.3% of patients with burn injuries at admission, and after seven days in hospital, an additional 15.7% of the patients with burn injuries presented with malnutrition (Kingu et al. 2011). Malnutrition on account of impaired endocrinal function might also develop and will affect wound healing and precipitate infection (Hettiaratchy and Dziewulski, 2004; Orgill, 2009; Stechmiller, 2010; Kasten, Makley and Kagan, 2011). In order to promote good nutrition and wound healing and reduce the hypercatabolism associated with burn injury, acute supplemental nutrition should be administered through enteral and parenteral feeding, vitamins and steroid supplements (Kasten, Makley and Kagan, 2011; Kingu et al. 2011).

2.8.3 Pain and Abnormal Sensation

A chief complication of patients with major burn injuries includes that of pain relating to the surgery sites, physiotherapy and the changing of wound dressings (episodic procedural pain), as well as a continuous background pain (or resting pain, an almost constant pain at the site of injury or donor site) (Esselman, 2007; Orgill, 2009; Judkins and Clark, 2010;

Griggs et al., 2017). In this case, the pain is challenging to treat as it is multifaceted and it changes in response to the diverse treatments that the patient endures (Orgill, 2009). Pain management is important regarding interventions that are painful, as well as for the background pain (Hanekom et al. 2015). Five percent to 52% of patients recovering from burn injuries experience sensory abnormalities and 10 to 87% experience paraesthesia (Vetrichevvel et al., 2017). Another complication includes pruritus, occurring in 58% of patients with burn injuries (Esselman, 2007). Pruritus has been seen to affect the QOL of patients with major burn injury (Esselman, 2007).

2.8.4 Thermoregulation

After a major burn, the body's thermoregulator is also affected, causing it to raise the temperature to 38,5 degrees Celsius (Esselman, 2007; Hanekom et al. 2015). Specifically, in instances whereby the burn injury is of full thickness, there is a loss of sweat glands, thereby disturbing the body's ability to thermo-regulate (Esselman, 2007; Hanekom et al. 2015). This affects the patient's ability to complete tasks and work in hot environments due to the sensitivity of the body to heat as well as an inadequacy in regulating the body's temperature (Esselman, 2007). On account of the metabolic response, systemic inflammation, or an infection, causes hyperthermia, which could cause cell injury or death, particularly if the temperature is continuously above 40 degrees Celsius (Hanekom et al. 2015). The burn unit should be at a particular temperature to aid the thermo-regulation of the patient.

Hypothermia is more prevalent in larger burns, as Singer et al. (2010) noted. This study stated that 35% of patients with a burn injury occupying over 70% of the TBSA presented with hypothermia (Singer et al. 2010). Hypothermia occurs on account of homeostasis failure and in that the body loses heat through the exposed tissue, which might even cause mortality (Singer et al., 2010). To manage hypothermia, warming blankets may be used; the patient's room should be heated, as well as the intravenous fluids that he/she ingests (Zenoni, Smith and Cheatham, 2018).

2.8.5 Systemic Inflammatory Response

Fifty to eighty-four percent (50 to 84%) of the deaths occurring in patients with burn injuries are related to sepsis (Lopez et al. 2017). Within the first 24 hours subsequent to the burn incident, a systemic inflammatory response syndrome transpires due to the inflammatory mediator release into the vasculature (Hanekom et al. 2015). Major burn injuries are associated with chronic inflammation, which essentially leads to multiple organ failure in response to the systemic inflammatory response syndrome, as well as to fibrosis and scarring (Strudwick and Cowin, 2018). Sepsis may also lead toward coagulations and a drop in the platelet level and could lead to disseminated intravascular coagulopathy (Greenhalgh, 2017). It has been noted, in the initial healing phases, that extreme inflammation can cause scar formation (Strudwick and Cowin, 2018). Immediate effective treatment and the early fluid resuscitation of a patient with a major burn injury significantly reduces the risk of mortality and complications, including fibrosis and scarring, systemic inflammatory response syndrome and multiple organ failure, that result from inflammation (Hanekom et al. 2015; Strudwick and Cowin, 2018). Other methods for managing major burns include antimicrobial treatment, vasopressor treatment and controlling the source of infection (Lopez et al. 2017).

2.8.6 **Multiple Organ Dysfunction Syndrome**

Multiple organ failure is associated with many complications but is a complication in itself. Multiple organ dysfunction syndrome is a continuum of infection and is preceded by systemic inflammatory response syndrome, which most of the patients with major burn injuries experience, whether they have an infection or not (Sullivan et al. 2006; Dahiya, 2009; Greenhalgh, 2017; Gauglitz et al. 2018). In patients with burn injuries, and provided that they have survived burns shock, multiple organ dysfunction syndrome is the principal cause of mortality (Greenhalgh, 2017). It has been noted that around 50% of patients with burn injuries may develop multiple organ dysfunction syndrome (Gauglitz et al. 2018). Severe sepsis has a significant risk of developing in patients with major burn injuries on account of the protective skin barrier lost, the depression of the various immune systems, invasive line insertion and increased catabolism (Kasten, Makley and Kagan, 2011; Hanekom et al. 2015; Greenhalgh, 2017).

2.8.7 **ICU Acquired Weakness**

As a patient with a major burn injury undergoes metabolic stress, as well as multiple organ failure and sepsis, the risk that he/she could develop ICU acquired weakness is significantly enhanced (Eagen, Ramdharry and Smailes, 2018). The hypermetabolic state, as well as bed-rest, in turn causes the catabolism or the de-conditioning of the muscles which could cause disability and last for six months to several years (Hettiaratchy and Dziewulski, 2004; de Lateur et al. 2007; Corner et al., 2015; Hanekom et al. 2015; Greenhalgh, 2017; Nielson et al. 2017). ICU acquired weakness involves a critical illness polyneuropathy, disuse atrophy and critical illness myopathy, all of which could be experienced in combination by a patient or as a single subgroup (Hettiaratchy and Dziewulski, 2004; Corner et al., 2015; Hanekom et al. 2015; Greenhalgh, 2017; Nielson et al. 2017). ICU acquired weakness is largely associated with immobility, multiple organ failure, sepsis, an extended period of mechanical ventilation, a need for pharmacology, a prolonged hospital LOS and rehabilitation, and an increased mortality rate (Kress and Hall, 2014; Jolley et al. 2016;

Nielson et al. 2017; Eagen, Ramdharry and Smailes, 2018). Kress and Hall (2014) and Jolley et al. (2016) noted that along with muscular weakness in the limbs, the respiratory muscles may also become weakened rendering the weaning from mechanical ventilation problematical. ICU acquired weakness is further exacerbated in patients with major burn injuries on account of the excisions performed surgically and the necrotic tissue that is de-vitalised or dead (Swezey, 2013; Eagen, Ramdharry and Smailes, 2018). Eagen, Ramdharry and Smailes, (2018) noted an increased mortality rate of 30%, decreased mobility of 70% at the five-year follow-up mark, and continual muscle weakness in the long term, with diminished neuromuscular function and higher rates of mortality continuing up to 15 years after discharge in patients that were diagnosed with ICU acquired weakness. Prevention strategies for ICU acquired weakness include early mobilisation, insulin treatment (preventing hyperglycaemia), sepsis treatment, and abstaining from using parenteral feeds in Week 1 of the ICU stay (Hermans and Van den Berghe, 2015).

2.8.8 **Cachexia**

Skeletal muscle plays an important role in regulating metabolism (Nielson, et al. 2017). There is an amino-acid store in the body, which provides fuel to the vital functions, which include acute protein synthesis and the deposition of new skin (Nielson, et al. 2017; Polychronopoulou et al. 2018). In a patient with burn injuries, cachexia arises due to the primary mechanism of critical illness-induced muscle wasting (preceded by inflammation and metabolic muscle catabolism), which includes protein degradation - a proteasome-mediated and/or loss of muscle mass by apoptosis (Tzika et al. 2009; Nielson et al. 2017; Klein et al. 2018). A burn injury results in the mitochondrial dysfunction of the skeletal muscles generates a significant amount of heat, which increases the metabolic rate (Tzika et al. 2009; Nielson et al. 2017). Furthermore, after a burn injury, the inflammatory mediators of the body cause damage to the heart, as well as to other organs in the body (Nielson et al. 2017).

2.8.9 **Acute Kidney Injury**

Acute kidney injury could commence in an early phase (during resuscitation) or at a late phase (as a secondary side effect to sepsis) in patients with major burn injuries and is related to early onset of multiple organ dysfunction syndrome, as well as a higher mortality risk (Coca et al. 2007; Brusselaers et al. 2010; Clark et al. 2017; Nielson et al. 2017). The type, size, severity and depth of the burn injury, including the presence of systemic inflammatory response syndrome, contribute to the occurrence of acute kidney injury (Coca et al. 2007; Brusselaers et al. 2010; Nielson et al. 2017). Nielson et al. (2017) noted that 87% of the patients with major burn injuries that develop acute renal failure have sepsis or are in septic shock (Coca et al. 2007; Clark et al. 2017; Nielson et al. 2017). A delay in fluid resuscitation is associated with severe acute kidney injury (Coca et al. 2007). Preserving renal perfusion, as well as performing fluid resuscitation at an early stage, are methods that could be used to avert acute kidney injury (Nielson et al. 2017). Renal dialysis is seen to be efficient in decreasing the rate of death in patients with acute kidney injury (Nielson et al., 2017).

2.8.10 Pulmonary Complications

As discussed previously, inhalation injury causes oedema in the lungs, as well as airway obstruction, haemorrhage, congestion, ulceration, infection, laryngospasm, and bronchospasm, and increases the likelihood of pneumonia and atelectasis (partial or complete) (Hanekom et al. 2015; Nielson et al. 2017). Inhalation injury, coupled with prolonged bed-rest, could cause a reduction in the capacity of the lung and in its functional residual volume, which could lead to a compromised gaseous exchange and decreased oxygenation (Hanekom et al. 2015). In patients with major burns, respiratory failure is likely (Nielson et al. 2017). It can be distinguished by a tendency for the hypoxaemia to lead to an acute respiratory distress syndrome or an acute lung injury (Nielson et al. 2017). Twenty-six percent (26%) of the patients with burn injuries in ICU develop acute respiratory distress syndrome (Lam and Hung, 2019). As discussed in Section 2.5 earlier on, and in Section 2.9 later on, a patient with an inhalation injury needs supportive treatment (Nielson et al. 2017).

Another pulmonary complication is extubation failure. The independent risk factors of extubation failure in a trauma population include initial airway intubation, a low extubation Glasgow Coma Scale (GCS), *delirium tremens,* and a spinal fracture (Brown et al. 2011). The most common motivation for re-intubation is respiratory failure (Brown et al. 2011). A failed extubation leads to an increased LOS in ICU and hospital (Brown et al. 2011). Other risk factors for re-intubation include self-extubation, delirium, increased age, opioid (enteral use), and moderate and copious secretion levels (Michetti et al. 2018; Mahmood et al. 2019). It was found that the percentage of failed extubation, with the need for re-intubation, in trauma patients, ranged from six percent to 30.7% (Brown et al. 2011; Michetti et al. 2018; Mahmood et al. 2019).

2.8.11 Central Nervous System

Hypoxia at a cellular level can cause an increase in intracranial pressure and thus cerebral oedema (Nielson, et al. 2017). Infections of the central nervous system have been shown to be present in a mere 0.1% of patients with major burn injuries (Calvano et al. 2010). Central nervous system disorder can present with symptoms such as confusion, agitation, temporary loss of consciousness, shock, seizures, ataxia and abnormal posturing (Nielson et al. 2017). As described in section 2.8.7 above, neuropathy frequently occurs in patients with major burn injuries and may involve one peripheral nerve (mononeuropathy) or a generalized polyneuropathy, thus affecting the strength and functional ability of the patient (Esselman, 2007).

2.8.12 Compartment Syndrome

Systemic burns, particularly those involving TBSA burn injuries of more than 60%, could cause abdominal compartment syndrome (1-20%) as well as intra-abdominal hypertension (36-70%), for which the cause is unknown (Nielson et al. 2017). To reduce the intra-abdominal pressure from the burns to the abdomen, an escharotomy and percutaneous drainage could be carried out, as could a laparotomy (Nielson, et al., 2017).

A circumferential burn that is deep threatens the limb by causing compartment syndrome as a result of the firm eschar that forms. Escharotomy and fasciotomy were discussed in Section 2.7. Early diagnosis and timeous treatment are key factors for preventing further morbidity or mortality associated with this complication (Sullivan et al. 2006; Ritenour et al. 2008; Tiwari, 2012; Giaquinto-Cilliers, 2014; Hanekom et al. 2015).

2.8.13 Amputation

Burn injuries could cause necrosis, which could lead to the amputation of the extremities and physical disability (Padilha, Muganza and Candy, 2016). Jang, Joo and Seo, (2018) noted that 38.9% of patients with burn injuries underwent major amputations and 61.1% received minor amputations. The most common type of amputation is the finger (Jang, Joo and Seo, 2018). Once a limb has been amputated, a prosthetic should be fitted, but this could be difficult owing to the existing contractures and the sensitivity of the skin (Esselman, 2007). Large amputations are a consequence of electrical burns, whereas thermal burns usually result in smaller amputations (Esselman, 2007). Amputations are likely to cause difficulties in the activities of daily living (ADLs) (Esselman, 2007). The range of motion (ROM) of the joints above the amputated limb, as well as the strength of the remaining musculature, should be improved and maintained including functional mobility aiming for independence (Ulger et al. 2018).

2.8.14 Musculoskeletal System

In patients with major burn injuries, the joints may be affected, thus resulting in ossification and contractures (Leblebici et al. 2006; Hanekom et al. 2015). Despite aggressive physiotherapy, a burn around a joint could still cause residual dysfunction and limit the physical roles that the patient performs (Leblebici et al., 2006; Hanekom et al. 2015). Contractures lead to joint and facial deformity, as well as decreased ROM (Esselman, 2007). Known predictors of contracture formation includes LOS, skin grafts, a large area covered by the burn injury, heterotopic ossification, immobility, and more commonly, hypertrophic scarring (Schneider et al. 2006; Esselman, 2007). Scarring is one of the late effects of deep burns and could cause contractures, deformity, pruritus, tenderness and hyperesthesia (Orgill, 2009).

2.8.14.1 **Hypertrophic scarring**

A common complication of a patient with a major burn injury is hypertrophic scarring, which occurs in 77% of the patients (Ault, Plaza and Paratz, 2017). It leads to psychological, as well as physical consequences, including limited ROM, pain, increased anxiety levels and a decreased health-related QOL (Ault, Plaza and Paratz, 2017). Hypertrophic scarring could form within one to two months after the initial injury, whereas keloids could form from months to years after the burn injury (Schmieder and Ferrer-Bruker, 2019). Its characteristics include scar tissue that is raised, red and rigid, thus restricting the normal movement of the skin which could lead to contractures and deformity (across joints) (Esselman, 2007; Hanekom et al. 2015). As the incidence and management of hypertrophic scarring is beyond the scope of this project, it will not be discussed further.

2.8.14.2 **Heterotrophic ossification**

Heterotrophic ossification has an unknown aetiology and occurs more frequently in females after a burn injury (Zou et al. 2011; Hanekom et al. 2015). It is rare, occurring in only one to three percent of patients with burn injuries (Tsionos, Leclercq and Rochet, 2004). It develops when bone is formed outside of the skeletal structure in patients with major burn injuries, particularly at the elbow joint (Vanden Bossche and Vanderstraeten, 2005; Zou et al. 2011; Hanekom et al. 2015). Possible causes of heterotrophic ossification have been reported to include repetitive microtrauma, forced passive movements, and an inflammatory response owing to injury to the tissues (Holavanahalli et al. 2011; Yeung et al. 2016).

2.9 PHYSIOTHERAPY MANAGEMENT

Rehabilitation is crucial in the management of patients with burn injury. The multidisciplinary team involved in patient rehabilitation should consist of physiotherapists, psychologists, occupational therapists, orthotists, social workers, anaesthetists, doctors and plastic surgeons, the nursing staff, dieticians, pharmacists, translators and interpreters, when indicated, speech and language therapists, case managers, clerical-care workers, and most importantly, the patient and his/her family (Orgill, 2009; Holavanahalli et al. 2011; Giaquinto-Cilliers, 2014; Hanekom et al. 2015). To work towards an increasing survival rate of a patient with major burn injuries calls for an accurate patient assessment, diagnosis and effective management, and furthermore, the prevention of and effective treatment of any complications that a patient might develop (Kasten, Makley and Kagan, 2011). The level of the treatment and its frequency are dependent on the needs of the patient and the stage of recovery that they are at. Rehabilitation should be commenced within the first 24 hours of hospital admission provided that the patient is stable enough (Holavanahalli et al. 2011). Rehabilitation may last years subsequent to a burn injury and thus the dedication of the patient to the process is imperative as is the commitment of the multidisciplinary team members (Spires et al. 2007).

Prior to the initiation of physiotherapy management, the therapist needs to consider the precautions and contra-indications related to his/her treatment of the patient. The precautions and contra-indications specific to patients with burn injuries is briefly discussed.

2.9.1 Precautions and Contra-Indications to the Physiotherapeutic Management of Patients with Burn Injury

Adult patients with burn injuries are vulnerable to infections and could develop sepsis (Rafla and Tredget, 2011; Hanekom et al. 2015). Thus, the physiotherapist should be attentive with regard to the infection control procedures of the Burns Unit such as the washing of hands, the wearing of protective gear, and the correct disinfection of all equipment used to limit infectious transfer to the patient (Kasten, Makley and Kagan, 2011; Rafla and Tredget, 2011; Hanekom et al. 2015).

Pain management is important when treating a patient with burn injury and should be co-ordinated as it aids their general and pulmonary functions (Esselman, 2007; Hanekom et al. 2015). The patient should receive long-acting pain medication to manage his/her background pain, and short-acting pain medication for the duration of a nursing or physiotherapy procedure or treatment (Esselman, 2007). Pain relief must be adequate enough to reduce the anxiety of the patient when a painful treatment technique (e.g. functional activity) needs to be applied (Spires et al. 2007; Hanekom et al. 2015). Physiotherapy sessions should coincide with the most beneficial period of pain relief induced by the pain medication administered (Spires et al. 2007; Hanekom et al. 2015). These sessions may be dovetailed with wound dressing and washing practices in the unit. During these activities, more pain medication is delivered to the patient and thus their level of pain associated with rehabilitation activities may be lessened (Spires et al. 2007; Hanekom et al. 2015). It is, however, imperative to be mindful of the effects that the pain medication might have on the patient’s performance during rehabilitation such as drowsiness, nausea, limited effective communication, postural hypotension, fainting, and diminished memory (Hanekom et al. 2015).

Once an escharotomy has been performed, the mobility of the patient in this area is not limited provided that the patient is not bleeding at the site of the surgery (Hanekom et al. 2015). If so, the physiotherapeutic treatment of the patient is ceased until a decision regarding the appropriateness of the time for continuing such treatment is discussed with the surgeon (Hanekom et al. 2015). Regarding a skin graft, it is widely recognized that the joints below and above the area which had received a skin graft should not be mobilised for a particular period of time post-surgery (usually three to five days) (Spires et al. 2007; Hanekom et al. 2015). However, the adverse effects of this inactivity should be considered during the decision-making process to determine the risks versus the benefits (Spires et al. 2007; Holavanahalli et al. 2011; Hanekom et al. 2015). Since prompt active movement might be considered (no passive movement), the surgeon should be consulted (Spires et al. 2007; Holavanahalli et al. 2011; Hanekom et al. 2015). Once the limb can be mobilised, it is important to note that harm could be done to the 'new skin' with stretching (Spires et al. 2007; Hanekom et al. 2015). As such, stretches should be performed in a gentle manner that is slow and lengthy with a recommended stretch being extended only to the point of blanching (Spires et al. 2007; Hanekom et al. 2015).

Patients with major burn and inhalation injuries are expected to need chest physiotherapy. The presence of an inhalation injury contra-indicates any postural drainage position which entails a head-down tilt as it may worsen the facial oedema and affect the airway patency (Hanekom, et al. 2015). Manual hyperinflation could cause damage to the airway cells and should, therefore, not be performed regularly during the acute phase of injury (Hanekom et al. 2015). Furthermore, the tip of a suction catheter should not extend beyond the end of the endotracheal tube as the already damaged cilia might undergo further damage (Mlcak, Suman and Hemdon, 2007; Hanekom et al. 2015). Suctioning should not be performed habitually (Hanekom et al. 2015). However, on occasion, or after secretion mobilisation, a tracheal aspirate is needed (Hanekom et al. 2015).

If there are acute burn wounds or new skin grafts to the chest, an alternative to manual chest physiotherapy practices should be used (e.g. humidification, oscillating positive expiratory pressure (PEP) therapy, and active cycle of breathing technique (ACBT)) to promote the movement of excessive secretions to the larger airways for expectoration and suction (Mlcak, Suman and Hemdon, 2007; Hanekom et al. 2015).

2.9.2 Aims of Physiotherapy Management of a Patient with Burn Injury

Physiotherapists are key members of the multidisciplinary team that cares for patients with burn injuries in ICU (Hanekom et al. 2015).

Education and continual support should be commenced from the start to the finish of patient care as it is an important part of a comprehensive, effective and holistic physiotherapy treatment programme, and involves not only the patient, but also the caregivers, family and if need be, the staff (Hanekom et al. 2015).

2.9.2.1 Cardiorespiratory rehabilitation

If the patient is intubated in ICU, on account of the seriousness of his/her injuries, it is essential for the physiotherapist to improve his/her oxygenation, humidification, secretion mobilisation and clearance processes, the lung volumes and, when the patient is awake and cooperative, to start respiratory muscle training to enable mechanical ventilation weaning (Hanekom et al. 2015). This topic will be expanded upon below.

While intubated and ventilated, the patient could be placed in different positions in bed in order to maximise his/her ventilation/perfusion ratio, which in turn enhances his/her oxygenation (Hanekom et al. 2015). Mechanical ventilation causes a ventilation/perfusion mismatch as the airflow follows the path of least resistance to the uppermost lung segments, and the perfusion in the lungs is more prevalent in the lowermost segments (Hanekom et al. 2015). However, positioning the patient at a 45 to 60-degree head-up tilt position allows for better ventilation/perfusion matching and reduces the risk of aspiration (Hanekom et al. 2015). A patient with burn injuries also needs humidification, which can be administered by a heat-moisture exchanger, a heated water humidifier (in the presence of infectious and tenacious secretions), as well as a nebuliser connected to the ventilator circuit which could administer saline or other medication, as required (Al Ashry and Modrykamien, 2014; Hanekom et al. 2015). Humidification helps loosen the secretions which aids airway clearance.

Secretion clearance is largely reliant on the function of the mucocilliary escalator, as well as the ability to cough (spontaneous or reflexive) (Fink, 2007; Mlcak, Suman and Hemdon, 2007; Hanekom et al. 2015). A cough causes an expiratory flow strong enough to extricate the secretions from the airway walls (Fink, 2007; Mlcak, Suman and Hemdon, 2007; Hanekom et al. 2015). However, as the cilia are damaged in an inhalation injury, a therapeutic cough is necessitated to promote the removal of secretions (Fink, 2007; Mlcak, Suman and Hemdon, 2007; Hanekom et al. 2015). The ability to cough may be hindered by the analgesia or sedation medication that the patient is receiving, his/her level of pain, or the presence of an artificial airway (Mlcak, Suman and Hemdon, 2007). As long as no burn injuries are present, manual hyperinflation can elicit a cough in conjunction with chest wall shakes and vibrations on exhalation (Mlcak, Suman and Hemdon, 2007). With the precautions and contra-indications in mind, a head-down tilt once the oedema has subsided, in conjunction with the application of manual hyperinflation, would enhance the clearance of secretions and the rate of expiratory flow (Berney, Denehy and Pretto, 2004; Hanekom et al. 2015). Though there is not enough evidence, it has been noted that mechanical insufflation-exsufflation can be used for secretion clearance, thus nullifying the need to perform manual chest therapy techniques (Hanekom et al. 2015).

Positive expiratory pressure (PEP) on the ventilator is used to re-establish the residual capacity of the pulmonary function and oxygenation in intubated patients (Hanekom et al. 2015; McIlwaine, Button and Dwan, 2015). Positive expiratory pressure pushes gas via the collateral ventilation units of the lung, and behind the secretions, thereby facilitating the clearance of the secretions (McIlwaine, Button and Dwan, 2015). After extubation, and in order to maintain lung capacity and volumes, PEP therapy could continue in the form of a blow bottle or a flutter device (oscillating PEP levels respectively) or a PEP mask (continuous PEP levels) (Hanekom et al. 2015; Hanekom et al. 2015a).

Deep breathing exercises promote lung expansion, the movement of secretions and are important for an effective cough (Fink, 2007). The active cycle of breathing (ACBT) incorporates exercises for thoracic expansion, breathing control and forced expiratory techniques (Fink, 2007). Active cycle of breathing technique should be applied when the patient is awake and cooperative, with the specific focus being on the thoracic expansion exercise portion of ACBT in order to improve the lung volumes and respiratory muscle strength for those on prolonged mechanical ventilation (Hanekom et al. 2015). This may be done in conjunction with biofeedback from the mechanical ventilator in intubated patients where the patient attempts to change the tidal volumes on the ventilator screen during active deep breathing (Hanekom et al. 2015). Respiratory muscle strengthening can be promoted by applying resistance to the diaphragm or chest wall during ACBT with mechanical ventilation biofeedback, as well as by increasing the time spent on respiratory muscle strength training during physiotherapy sessions (Hanekom et al. 2015). The inspiratory muscle training may be further intensified by temporarily reducing the trigger sensitivity or pressure support settings on the ventilator, which should be discussed with the attending doctor, while the patient performs ACBT with resistance applied to the chest wall. A spring-loaded inspiratory muscle trainer device that poses resistance to inspiration might also be used if the patient is able to breath off the mechanical ventilation for a few minutes at a time (Hanekom et al. 2015). The patient's vitals should be monitored throughout the training period and the patient should not be subjected to overexertion as this may prolong the weaning process (Hanekom et al. 2015; Gomes-Neto et al. 2016; Menezes et al. 2016). Once extubated, and to encourage inspiratory volume, the patient may continue with ACBT or use intermittent positive pressure breathing or incentive spirometry and active exercise therapy (Hanekom et al., 2015a).

Once the patient is spontaneously breathing and possibly extubated, the same physiotherapy principles might apply. However, patient treatment then becomes a more active process since it includes mobilisation out of bed to clear the chest (Hanekom et al. 2015). Two-hourly deep breathing and coughing exercises could reduce secretion retention in patients with inhalation injury (Mlcak, Suman and Hemdon, 2007; Hanekom et al. 2015). If the patient is weak or in excessive pain, ACBT may be conducted in conjunction with manual chest therapy techniques (percussions, vibrations, and shaking) in a modified postural drainage position to facilitate secretion clearance (Mlcak, Suman and Hemdon, 2007; Hanekom et al. 2015). Yankauer's suction to the back of the throat could support secretion clearance (Hanekom et al. 2015). The most advantageous treatment to optimise lung volume and airway clearance includes the combination of mobilisation, deep breathing, suctioning and coughing (Mlcak, Suman and Hemdon, 2007; Hanekom et al. 2015). There has been a gradual step away from traditional techniques regarding airway clearance (e.g. breathing exercises), toward active exercise (Berney et al. 2012; Denehy et al. 2018). This does not detract from the importance of airway clearance techniques but highlights the importance of exercise training in respiratory conditions (Denehy et al. 2018). Health related QOL, symptoms and exercise tolerance improve with pulmonary rehabilitation (Denehy et al. 2018). The exercise training that can be used in pulmonary rehabilitation includes resistance exercises, functional training, continuous moderate intensity endurance training, respiratory muscle training, upper limb training and treadmill training to name a few (Berney et al. 2012; Denehy et al. 2018). Another study found high intensity exercise to be valuable in cardiorespiratory fitness (ability of the circulatory and respiratory systems to supply oxygen to skeletal muscles during exertion) (Marques et al. 2019; Luo et al. 2020). In conclusion, treatment techniques that are now used for the cardiopulmonary system include humidification, airway clearance techniques, breathing re-education, thoracic mobility exercises, positioning and active exercise (McIlwaine, 2006).

2.9.2.2 Musculoskeletal rehabilitation

With regard to the musculoskeletal system, the splinting of affected limbs to prevent the shortening of two-joint muscles (contractures), the joint range-of-motion exercises, muscle-strength training, and early mobilisation should start in the ICU, in order to maintain and improve muscle strength as well as endurance, and should be continued until full integration into society has been achieved (Esselman et al. 2006; Spires et al. 2007; Procter, 2010; Hanekom et al. 2015).

Rehabilitation consists of four levels, starting with passive ROM, anti-contracture positioning, two-hourly positioning, and ending with out-of-bed mobility, the use of weights and therabands for resistance training (Esselman et al. 2006; Spires et al. 2007; Holavanahalli et al. 2011; Clark et al. 2013; Hanekom et al. 2015). Willis et al. (2011) suggested that an allowance be made for recovery time between exercises for arterial saturation to increase in order to mitigate the onset of patient fatigue. It should be noted that positions to prevent contractures should be provided by the physiotherapist and adhered to by the patient, family and the multidisciplinary team members (Hanekom et al. 2015).

Range of motion exercises and positioning are important in patients with burns that cover more than 20% of the TBSA, in inhalation injuries, in deep partial and full thickness burns and in amputations (Spires et al. 2007; Hanekom et al. 2015). Patients in such cases are challenged with an increased risk for compression neuropathies and the formation of contractures (Spires et al. 2007; Ferguson et al. 2010; Hanekom et al. 2015).

The physiotherapist should be present during dressing changes or bath activities in order to assess the extent of the burn wounds (depth, area, healing) (Hanekom et al. 2015). It is important to keep in mind that the physiotherapist could and should perform ROM exercises during the change of dressings and the bathing of the patient in order to reach the full ROM under effective pain control, and specifically for the fingers and the hand (Procter, 2010; Hanekom et al. 2015). Furthermore, the physiotherapist should be aware of any ROM shortcomings and possible limitations to a joint in order to carry out ROM (passive or active) and positioning exercises without harm (Procter, 2010; Hanekom et al. 2015).

As the rehabilitation process starts with passive ROM, full ROM should be reached at least once a day in the case of each affected joint (Esselman et al. 2006; Spires et al. 2007; Hanekom et al. 2015). Furthermore, all of the movements allowed at each affected joint should maintain the extensibility of the muscle and joint ROM (Spires et al. 2007; Hanekom et al. 2015).

Passive movements may be executed in the form of passive cycling. Though there is a lack of data regarding passive cycling in patients with burn injuries, it was found that an enhancement of endurance, functional ability and a reduction in hospital LOS were possible for patients without burn injuries who passively cycled for 20 minutes a day (Burtin et al. 2009). These results could translate to patients with burn injuries. As the patient awakens, passive exercising could become more active as active-assisted, active, and active-resisted exercises, but with the precautions and contra-indications and the restrictions they place on therapy techniques in mind (Spires et al. 2007; Hanekom et al. 2015).

Once the patient is awake, ROM becomes more active and progresses from active-assisted to active-resisted exercises, including stretching (slow and sustained with repeated repetitions to the end of range and followed by a prolonged end-of-range stretch), proprioceptive exercises, and mobilisation (Esselman et al, 2006; Spires et al. 2007; Hanekom et al. 2015). In preparation for exercise training, the proprioception of the patient should be assessed and enhanced where needed by the use of bracing, strapping and manual therapy as this is seen to instantly improve proprioception (Clark et al. 2015). Clark et al. (2015) suggested exercise techniques that can be beneficial to long-term proprioception, namely, muscle performance, repositioning of a joint (actively) and co-ordination exercises which is progressed to balance exercises and plyometrics. When the patient is extubated and spontaneously breathing, the physiotherapists should educate the patients on the importance of positioning and stretching to avoid the formation of contractures and to add these activities to their ADLs, thus allowing for patient autonomy (Hanekom et al. 2015).

If a patient has a decreased passive ROM, proprioceptive neurofacilitation methods could be used (Hanekom et al. 2015). Depending on the technique needed, they would include contract-relax, rhythmic stabilisation or hold-relax exercises (Hanekom et al. 2015). This technique could prevent complications after a prolonged period of immobilisation of a limb on account of burns (Reznik, Biros and Bartur, 2015).

Effective techniques that could be implemented for strengthening patients with burn injuries include isometric, isotonic and isokinetic exercises (Spires et al. 2007; Ahmed et al. 2011; Holavanahalli et al. 2011). One should be mindful, however, that exercise regimens should be designed to be specific to the needs of the patient, structured and progressive (Spires et al. 2007; Ahmed et al. 2011; Holavanahalli et al. 2011). Isokinetic exercises, specifically, were found to improve the patient’s eccentric and concentric muscle strength (Ahmed et al. 2011). The muscle strength of the unaffected areas should be maintained and the muscle strength of the affected areas should be optimised (Hanekom et al. 2015). Resistance training could be performed using the patient’s own body weight, water bottles, ankle or wrist weights, or exercise bands, but strict adherence to the infection control policies of the unit is important. The patient should be involved in a conditioning programme involving strength and endurance training (Spires et al. 2007; Holavanahalli et al. 2011), which would in turn promote patient mobility. Another way to improve the patient’s distance walked in the time from ICU discharge to discharge from the hospital, would be to use high-intensity exercise training (aerobic and resistance exercises) as proposed by Paratz et al. (2012) for their cohort of patients with major burn injury. Esselman et al. (2006), stated the support for aerobic exercise and the use of a progressive resistance training program.

Early mobilisation should be determined via the medical stability of the patient, their motor and cognitive abilities, the presence or absence of contra-indications, the type of surgery performed, and the need for bed-rest thereafter. The mobility of a patient with burn injuries is of utmost importance and should be initiated in the management plan as soon as it is appropriate as studies have shown that early mobilisation reduces delirium, the mechanical ventilation days and contracture formation (Spires et al. 2007; Schweickert and Kress, 2011; Mendez-Tellez and Needham, 2012; Hanekom et al. 2015; Corcoran et al. 2016; Tipping et al. 2017). Furthermore, early mobilisation also improves muscle strength, muscle tone, ventilation and the number of days alive, as well as reducing the need for post-acute care therapy (Spires et al. 2007; Schweickert and Kress, 2011; Mendez-Tellez and Needham, 2012; Hanekom et al. 2015; Corcoran et al. 2016; Tipping et al. 2017). However, a common delay in mobility could be due to orthostatic intolerance, which might result from burn wounds to the legs (Spires et al. 2007; Schweickert and Kress, 2011; Mendez-Tellez and Needham, 2012; Hanekom et al. 2015; Corcoran et al. 2016; Tipping et al. 2017).

To initiate patient mobilisation, functional activities such as transfers in and out of bed and ADLs, mobilisation away from the bedside, activities in order to retrain balance and posture, and activities to enhance cardiovascular endurance, should be incorporated into the patient's rehabilitation programme (Procter, 2010; Hanekom et al. 2015). Standing balance needs to be assessed before the patient walks, allowing mobility over short distances several times a day, with the distance increasing as the patient improves (Hanekom et al. 2015). Gait re-education and posture should form part of the rehabilitation programme as soon as the patient begins to mobilise. It has been suggested that the Unna boot and elastic bandage wraps be applied to the leg and foot to permit early mobilisation post-surgery, thus reducing the patient's hospital LOS (Holavanahalli et al. 2011). The patient's pre-morbid independent mobilisation should be achieved by weaning the patient off any walking aids that they might have initially used for mobility at the time of hospital discharge (Hanekom et al. 2015).

It is important to note that disturbances in the gait may be resolved as the wounds heal (Spires et al. 2007). However, some might persist beyond the healing of the wound and are dependent on the cause of the disturbance (e.g. pain, altered sensation) (Spires et al. 2007). Aggressive physiotherapy, also termed early assertive and vigorous therapy, and therapeutic positioning should be aimed at preventing these complications and commenced at an early stage in the hospital stay (Schneider et al. 2006; Spires et al. 2007; Procter, 2010). As the wounds heal and the patient recovers, endurance exercises should begin, with the implementation of progressive exercises such as star jumps, fast walking, cycling, stepping, and stairclimbing (Hanekom et al. 2015). Independence in ADLs should improve as the patient's exercise endurance improves (Hanekom et al. 2015).

Before discharge from the hospital a patient with major burn injuries must have a functional assessment, as well as an assessment of his/her capability to accomplish ADLs (Hanekom et al. 2015). With these assessments in hand, the multidisciplinary team, patient and the family can deliberate on the goals for on-going rehabilitation following hospital discharge (Hanekom et al. 2015).

2.10 RECORD KEEPING AND MEDICO-LEGAL IMPLICATIONS:

Accurate and detailed record keeping is an important professional requirement, as well as a necessary legal requirement for all health professionals (Phillips, Stiller and Williams, 2006; Wegner and Rhoda, 2011). To ensure appropriate patient care, correct record keeping allows for valuable communication across the entire spectrum of the multi-disciplinary team regarding the condition of the patient and his/her management, thus allowing for continuity of care (Phillips, Stiller and Williams, 2006; Wegner and Rhoda, 2011).

Richoz et al. (2011) noted that 83.4% of the physiotherapists that responded to their questionnaire admitted that they were unfamiliar with the legal requirements associated with record keeping. They attached great importance to every practice and its employees in keeping informed and correct records according to the legal requirements (Richoz et al. 2011). Of course, as record keeping becomes electronic, the requirements for record keeping might also change (Richoz et al. 2011). Preventative measures for court issues which have been noted to be the best include effective and dignified communication, as well as the provision of appropriate information (Richoz et al. 2011).

Correct record keeping is important not only for medico-legal reasons, but also for the purposes of research (Phillips, Stiller and Williams, 2006). The law in South Africa states that medical records in a health-care facility should be kept for at least six years after the discontinuation of patient care (Wegner and Rhoda, 2011). Missing medical records have grave consequences for the career of the health-care practitioner, the incidence of iatrogenic injury and the quality of health care (Wegner and Rhoda, 2011). Their loss also affects the capacity with which one can inform practice by conducting research (Wegner and Rhoda, 2011).

2.11 CONCLUSION

Since the decline in the mortality rates related to burn injuries, the emphasis of research has generally shifted from mortality risk to the functional outcomes of patients who sustained burn injuries (van Baar et al. 2006). Several reports indicate a delayed recovery period for patients who sustained major burn injuries in relation to upper limb function, the performance of self-care activities, endurance and walking ability, in some cases up to five years subsequent to discharge (Druery, Brown and Muller, 2005; Van Baar et al. 2006; Chapman et al. 2008; Willis et al. 2011; Koljonen et al. 2013). Owing to all of the detrimental effects a major burn injury has on patient recovery, it is important to focus patient treatment not only on overcoming the current problems challenging a patient, but also to limit his/her physical disability over the long term. Therefore, it is vital to identify factors that affect the level of physical function of patients recovering from major burn injury at the time of their hospital discharge. This knowledge will in future enable members of the rehabilitation team to identify patients at risk at an earlier stage during their period in hospital and to implement focused rehabilitation programmes that might improve their level of physical function at the time of discharge from the hospital.

CHAPTER 3

3. METHODS

This section explains how this record review was conducted. Included in this section is the study design, study population, study procedures, ethical considerations as well as means of data capturing and statistical analysis.

3.1 STUDY DESIGN

A retrospective record review has been conducted to meet the objectives of this research study. Recorded data in the patients' ICU charts, hospital files and physiotherapy notes were reviewed and only the information needed for this study was extracted. The challenge with a record review is that the data might not have been recorded reliably (Sarkar and Seshadri, 2014).

3.2 SUBJECTS

3.2.1 Study Population and the Physiotherapy Standard of Care Provision

The study population included adults who had sustained major burn injuries. Information about these patients was sourced from a private hospital in Johannesburg which has a Level 1 Trauma Centre and Burns Unit. In total, there are 365 beds in the hospital and 95 of those beds are dedicated to intensive- and high-care patients.

In the hospital in which this study was conducted, the physiotherapists abide by the following protocol:

- A sputum sample is extracted from patients with major burn injuries on admission, as well as on every Monday from all patients with an artificial airway. This sputum is tested for microscopy, culture and sensitivity. This applies to all artificial airways, including fenestrated tracheostomies.

- All patients in the Burns ICU are seen daily, including over weekends and public holidays. The patients are usually treated once a day. Should the patient have a compromised respiratory system, have been freshly extubated or present with copious secretions, treatment is then given twice a day. The treatment consists of chest modalities such as manual hyperinflation, suctioning, and musculoskeletal modalities such as passive movement, positioning and early mobilisation.

- Once the patient has been transferred to the ward, the physiotherapy treatment is continued daily, including over weekends and public holidays. This treatment includes joint mobilisation, stretches, wall exercises for combined movements (e.g. the bus-stop stretch: shoulder abduction, elbow extension, wrist fully extended or wrist flexed), and general strengthening exercises and stair climbing to increase the ability to perform ADLs and to increase the patient’s endurance and cardiovascular fitness.

3.2.2 Inclusion and Exclusion Criteria and the Sampling Method

All records of adults with major burn injuries that were admitted to and discharged from the Burns Unit of this private hospital and who were then transferred to and discharged from the general hospital ward over a 36-month period, were included for review. Consecutive sampling was used, provided that the patients had been diagnosed with burns of a TBSA of 20% or more (excluding superficial burns), and whether or not they had sustained an inhalation injury (Hettiaratchy and Papini, 2004; Borke, Zieve and Ogilvie, 2016; Gauglitz and Williams, 2016).

Records that were excluded from the study included the following:

3.2.2.1 Patients with complex lower limb injuries (previous to or as a result of injury) that would delay their recovery of full physical functions (e.g. those who had an amputation, those with spinal cord injuries and complex fractures to the pelvis, femur, tibia, and fibula,

3.2.2.2 Patients with cognitive disorders (diagnosed previous to or as a result of injury) that would delay physical activity (including those with traumatic brain injury),

3.2.2.3 Patients who had died in hospital.

3.2.3 Sample size calculation

A sample of convenience was used for this study. All of the records for the patients admitted to the Burns Unit and who were then subsequently transferred to the hospital ward were reviewed over a period of 12 months to identify patients that fitted the inclusion criteria for this study. Approximately 80 patients were admitted to the Burns Unit between January 2016 and December 2016 according to the existing records from the unit. Only 44 of these patients were categorised as having sustained major burn injuries. Therefore, it was decided to increase the data collection period to 36 months to increase the sample size that could be used for this study.

3.2.4 Variables

Independent Variables	Dependent Variables
Range of motion at hospital discharge	Number of surgical procedures performed
Function at hospital discharge	Length of stay in ICU and in hospital
Distance walked at hospital discharge	Type of complications developed in ICU
Muscle power at hospital discharge	Severity of injury

3.3 STUDY PROCEDURES

3.3.1 Outcome Measures/Instrumentation

A study-specific data extraction form was developed for this study (Appendix D) by the researcher and was used to record information relevant to the objectives of this study from the records retrieved from the private hospital's Burns Unit and wards. The information that was extracted for each included the patient's incorporated functional ability (FSS-ICU score – Appendix C), the joints affected by the burn injury, the ROM of these joints, muscle power and the distance walked (estimated by the physiotherapist) at different times; as well as the type of complications that developed, the length of stay in the ICU, the length of stay in the hospital, the severity of the injury on admission (ISS), the number of surgical procedures performed during the hospitalisation period, the percentage of the TBSA that sustained a burn injury (Rule of Nines), and the revised Baux score (prediction of mortality).

All of this information was recorded in the hospital and physiotherapy files. The data were collected from the point in time when the patient was admitted to the Burns Unit, at the point when the patient was transferred to the general ward, as well as at the point when the patient was discharged from the hospital.

3.3.2 Data Collection Procedure

With all permissions in place, the study commenced. Patients that were admitted to the Burns Unit, and subsequently transferred to the general ward with major burns over the 36-month period from January 2015 to December 2017 were identified from the Trauma Bank database. This was done according to the predetermined inclusion and exclusion criteria for the study and with the assistance of the trauma research nurse. Because the researcher (Irene Angelou) did not have access to the Trauma Bank database, the trauma research nurse identified patients who had sustained major burn injuries and whose data were captured on the Trauma Bank database. The trauma research nurse gave the researcher (IA) the contact details of these identified patients. In turn, the researcher contacted each individual patient, explained the aims of this research study to him/her and obtained his/her consent to use their data sourced from the Trauma Bank database (2015-2017) for the purposes of this retrospective study (see appendix E). Upon obtaining consent from each individual patient, the researcher informed the trauma research nurse as to who had given permission for their details to be extracted from the Trauma Bank database, and only that information was used for the purposes of this study.

The trauma research nurse extracted the data needed for this study as part of her normal duties and was thus not compensated. As such, she will be recognised in the publication of the results from this study. The trauma research nurse collated all of the relevant information of the identified patients into a separate Excel document. This document did not include any identifying patient information on it, thus assuring the anonymity of the respondents. This information was provided to the researcher for the purpose of data capturing on the designed data extraction sheets (see appendix D) for the study.

The trauma research nurse contacted the physiotherapy practice owner, who services the private hospital Burns Unit and wards, with the names of the identified patients from whom consent had been obtained so that the practice owner could select the relevant physiotherapy notes for these patients from her records. All identifying patient information was removed from the physiotherapy notes and the same encoding structure followed, as per the Trauma Bank database information supplied, to ensure that each individual patient's information had been collected correctly. The researcher then collected the encoded physiotherapy notes from the practice owner and captured the relevant information from the clinical notes onto the study data extraction sheets (see appendices C and D).

During the data-capturing process, the study supervisor evaluated a small portion of the data that had been captured to ensure that it had been done accurately. All of the data captured on the data extraction sheets was entered onto an Excel sheet to allow for the statistical analysis process.

3.4 ETHICAL CONSIDERATIONS:

The first step to negotiate for this study to commence was to apply for and obtain permission to perform the study from the University of the Witwatersrand's Human Research Ethics (Medical) Committee (Appendix I). This was obtained on the 30/10/2017 with the ethical clearance number of M171007. The hospital management at the private hospital was approached for permission to conduct the study (see letter in Appendix F). The Trauma Programme Manager at the private hospital was approached for permission to access the relevant patient information from the electronic database of the Trauma Bank database (see letter in Appendix G). Likewise, the owner of the physiotherapy practice that services the Burns ICU also gave permission to access the relevant patient information from her physiotherapy notes (see letter in Appendix H).

3.5 STATISTICAL ANALYSIS

Data was captured on an Excel spreadsheet. Incomplete data were managed by carrying through the last-observation-forward method, but excluded those patients who had died during hospitalisation. Data were imported into the IBM Statistical Package for the Social Sciences (SPSS) software programme (version 25) for analysis. Descriptive statistics were used to summarise the information obtained. The normality of the distribution of data was assessed using the Shapiro Wilk test. Continuous variables were summarised as means and standard deviations for normally distributed data or medians and interquartile ranges. Categorical data were summarised using numbers and percentages. The associations between ISS, ICU LOS, hospital LOS, number of theatre visits, and number of complications developed and the non-independent physical function status (FSS-ICU<35) of the patients at hospital discharge were performed using the binary logistic regression analysis method to establish the odds ratios. Testing was done at a level of significance of five percent (5%) (p-value≤0.05) and 95% confidence intervals were reported.

CHAPTER 4

4. RESULTS

This section presents the results obtained from the data collection process. The data collected in this study includes the demographic and clinical characteristics of patients; changes that patients experienced in physical function; number and type of complications developed; respective associations between ISS, ICU LOS, number of theatre visits, and number of complications developed and non-independent physical function (FSS-ICU<35) of patients at hospital discharge.

4.1 STUDY POPULATION:

Between January 2015 and December 2017, a total of 84 patients with major burn injury, and with or without inhalation injury, were admitted to the Trauma Burns Unit of a private hospital in Johannesburg. Of those 84 patients, five were excluded as they were paediatric patients, four were excluded as they had additional complex injuries that would delay their physical recovery, and two had incomplete data as there were no available physiotherapy notes for them. Of the included participants, none refused that the data pertaining to them be used in this study. None of the remaining 73 patients died in hospital and none had known cognitive disorders. As described in the previous chapter, all patients received standard physiotherapy care.

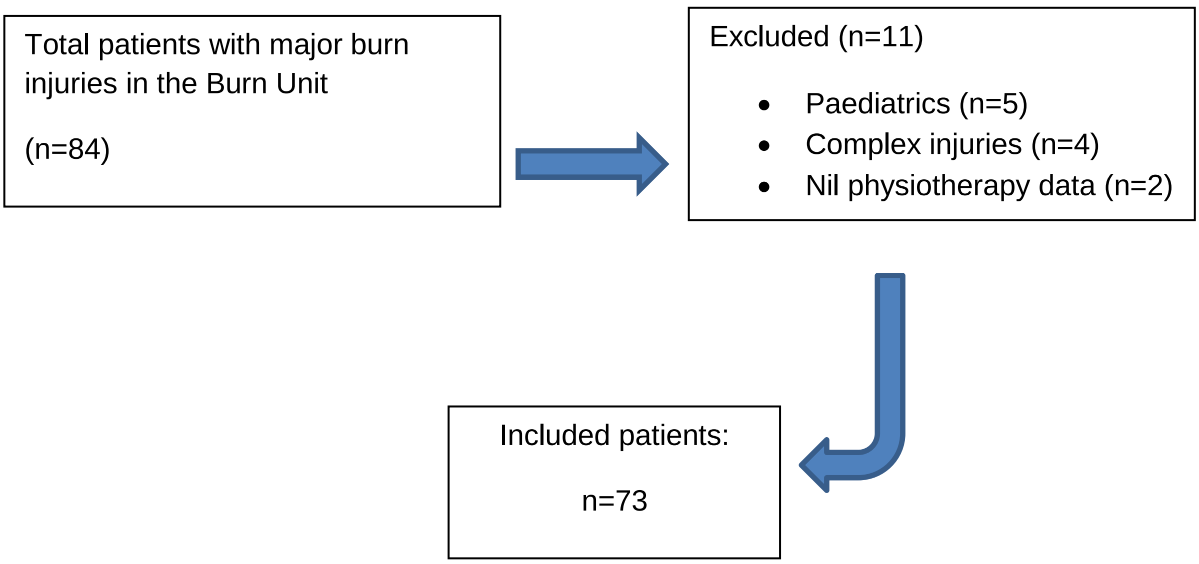


Figure 4.1: Summary of the Study Population

4.2 **DEMOGRAPHIC AND CLINICAL CHARACTERISTICS**

4.2.1 **Gender and Ethnicity**

Of the 73 patients included in this study, 87.7% (n=64) of the patients with major burn injuries were male. Figure 4.2 summarises the various ethnic groups included in this record review.

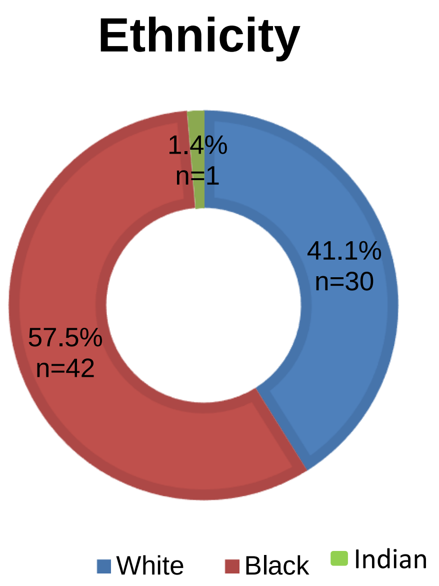


Figure 4.2: Summary of the Ethnicity of this Study Population (n=73)

Most of the patients included were black (n=42, 57.5%).

4.2.2 **Age**

The median age of the whole group was 38 years (IQR: 22). The minimum age was 19 years and the maximum age was 88 years.

4.2.3 **Mechanism and depth of injury**

Figure 4.3 summarises the various mechanisms of injury observed.

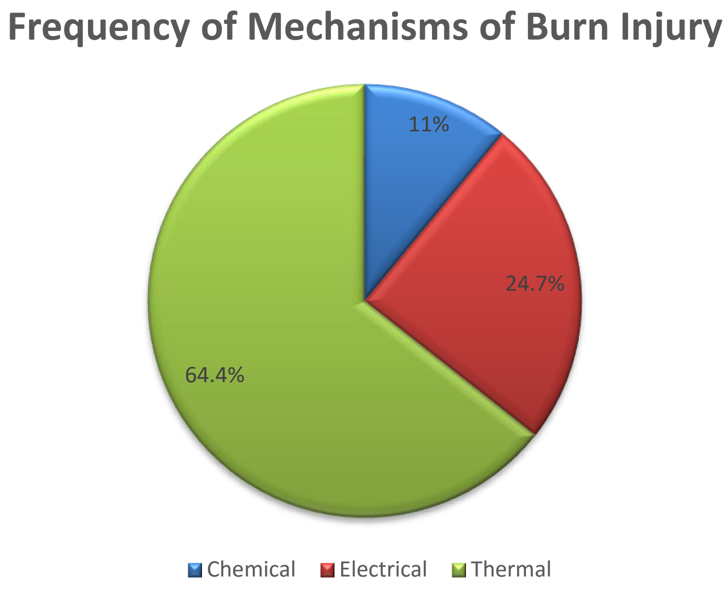


Figure 4.3: Distribution in Terms of Mechanism of Injury (n=73)

The majority of patients sustained thermal burn injury (n=47, 64.4%). Inhalation injury was recorded for 17 (23.3%) of the 73 patients with major burn injury.

Only 19 of the 73 patients had burn depth recorded in their files. Two patients (2.7%) sustained superficial burn injuries, eight patients (11%) sustained partial thickness burn injuries and nine patients (12.3%) had full thickness burn injuries. Burn depth was not recorded in 74% (n=54) of the study population although all included patients (n=73) were categorised by the Trauma Bank research nurse as having sustained a major burn injury.

4.2.4 **Body Areas and Percentage of TBSA Affected by Burns**

Figure 4.4 summarises the different areas of the body that were affected by burn injury.

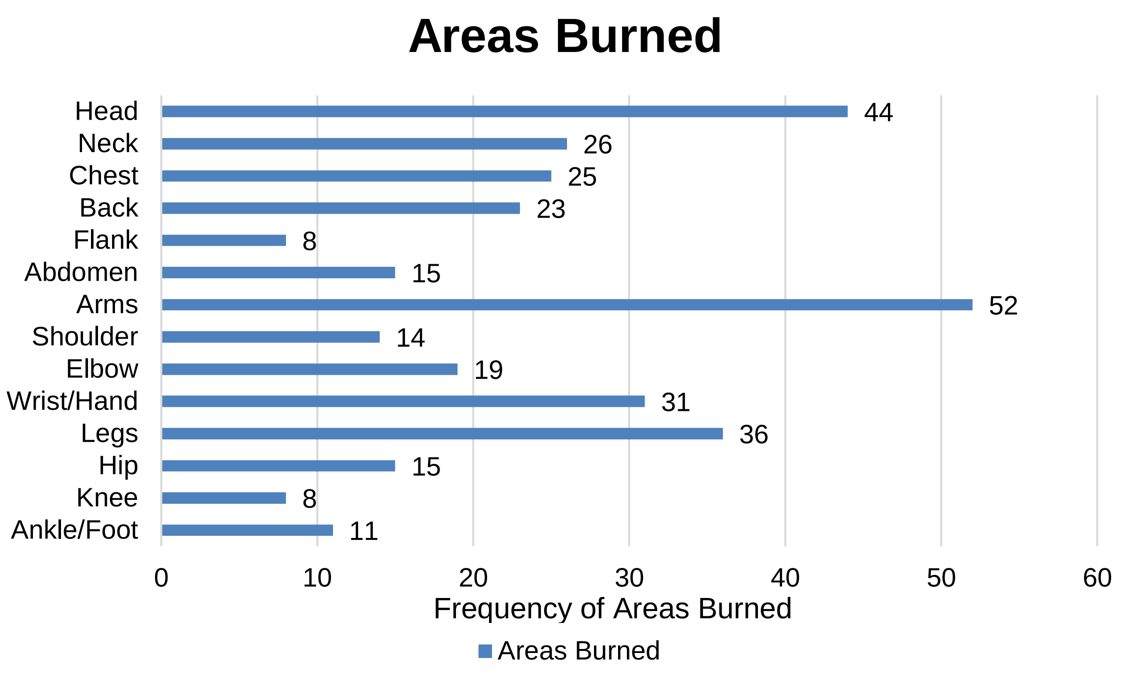


Figure 4.4: Summary of Areas Burned (n=71)

From the figure above, it is clear that in this study cohort the arms (73.2%; n=52), head (62%; n=44), and legs (50.7%; n=36) were mostly affected by major burn injury.

The total body surface area that was burned in this study cohort presented with a median of 31%TBSA (IQR: 20). The minimum TBSA burned was noted at 20% with a maximum of 77% TBSA burned leaving a range of TBSA of 57%. For further clarity, the data showed that 28 (38.4%) of the study cohort presented with TBSA affected of between 20%-29%, 20 (27.4%) of the study cohort experienced 30%-39% TBSA burns, 9 (12.3%) presented with 40%-49%TBSA burns, 7 (9.6%) presented with 50%-59% and 60%-69%TBSA burns respectively and lastly, 2 (2.7%) of the patients in this study cohort experienced TBSA burns between 70%-79%.

4.2.5 Severity of Injury and Risk for Mortality

The ISS data reported a minimum score of one and a maximum score of 32. The ISS median score was 16 (IQR: 16). As mentioned previously, an ISS of 15 or more in a major trauma poses a 10% risk of mortality (Palmer, 2007; Karadsheh and Taylor, 2018). As the median in this study population was 16, it can be said that half the patients presented with a risk of mortality of no less than 10%.

The mean Baux score was 78.5 (SD: 22.2) and the mean Revised Baux score was 93 (SD: 19.3). The minimum Revised Baux score came to 59 while the maximum reached 141 with

18 patients having a score of 100 or more. As mentioned previously, a 50% chance of mortality is true for those who score over 75; while a score of more than 100 suggests that the patient is destined for palliative care (Smith, Allorto and Clarke, 2016). Therefore, at least 50% of the study population were found to be at risk of mortality. Figure 4.5 below shows the frequency of patients in this study cohort that presented with the different Revised Baux scores.

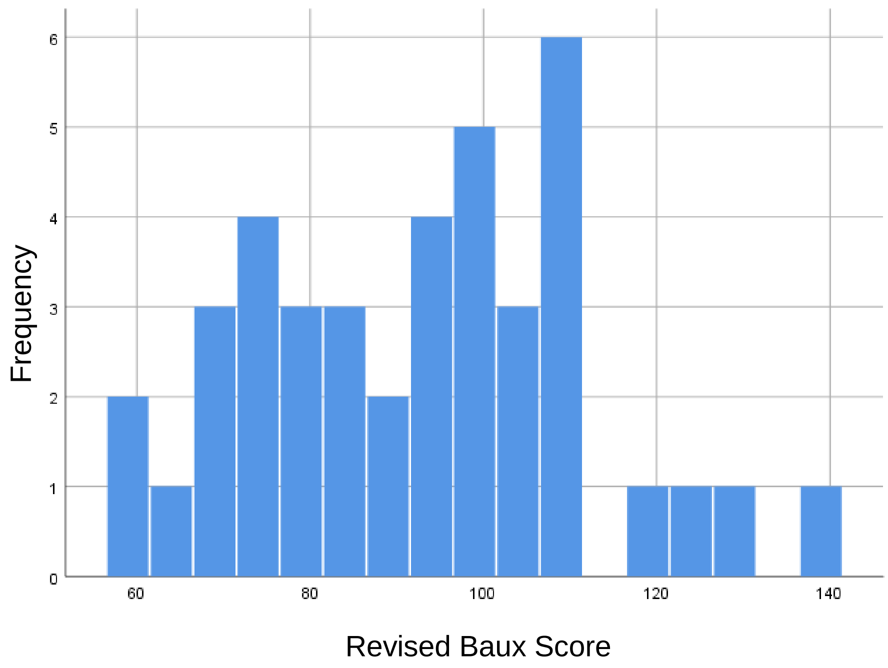


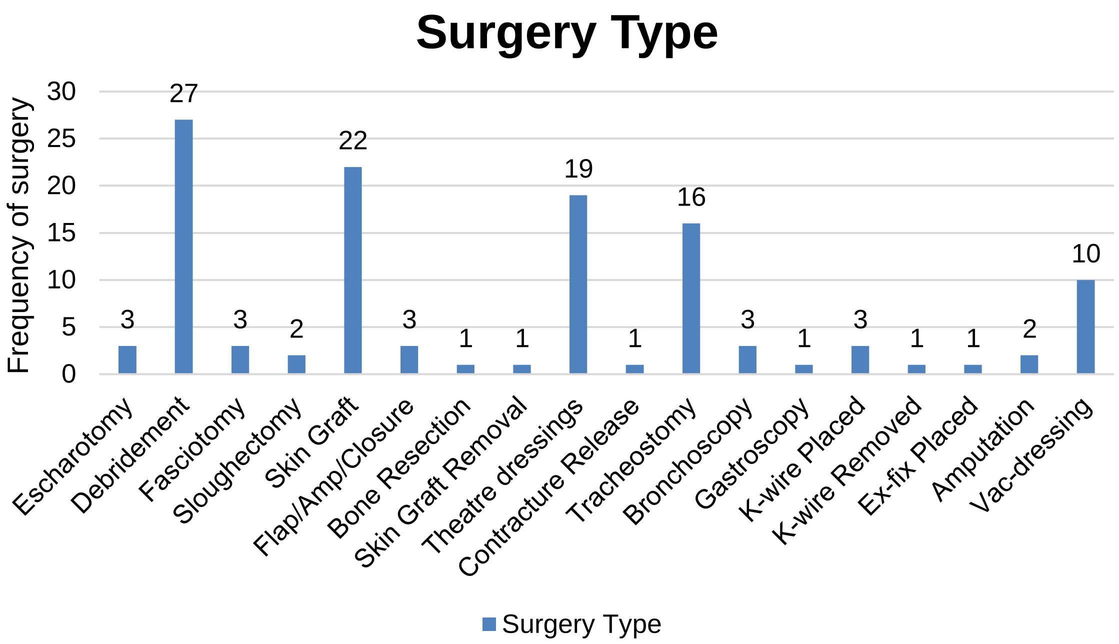
Figure 4.5: Frequency of Patients with Revised Baux Scores

4.2.6 Length of Stay

All 73 patients in this study population were admitted into the Burns Unit and transferred to a ward thereafter. The median ICU LOS for this cohort was 17 days (IQR: 34) with a minimum LOS of 0 days and a maximum LOS of 81 days. The median ward LOS for this cohort was 23 days (IQR: 24) with a minimum LOS of 0 days and a maximum LOS of 169 days. This cohort had a median LOS in the hospital of 44 days (IQR: 31) with a minimum LOS of seven (7) days and a maximum LOS of 243 days.

4.2.7 Surgical Procedures

A median of six surgeries (IQR: 9) were performed in this cohort of patients during their hospital stay. The minimum number of surgeries received was 0 and the maximum was 29. The types of surgical procedures performed on the cohort of 73 patients are summarised in the figure below.



*Amp - Amputation

Figure 4.6: Surgeries Needed in this Study Population (n=73)

The two most common types of surgical procedures performed for this cohort of patients were wound debridement (n=27) and skin grafts (n=22).

Table 4.1 represents the number of patients who needed sedation, mechanical ventilation and an artificial airway.

Table 4.1: Artificial Airways and Sedation needed in this Study Population (n=73)

	n	**%**
MV/Intubation	32	43.8%
Re-intubation	3	4.1%
Sedation	33	45.2%

MV - Mechanical ventilation

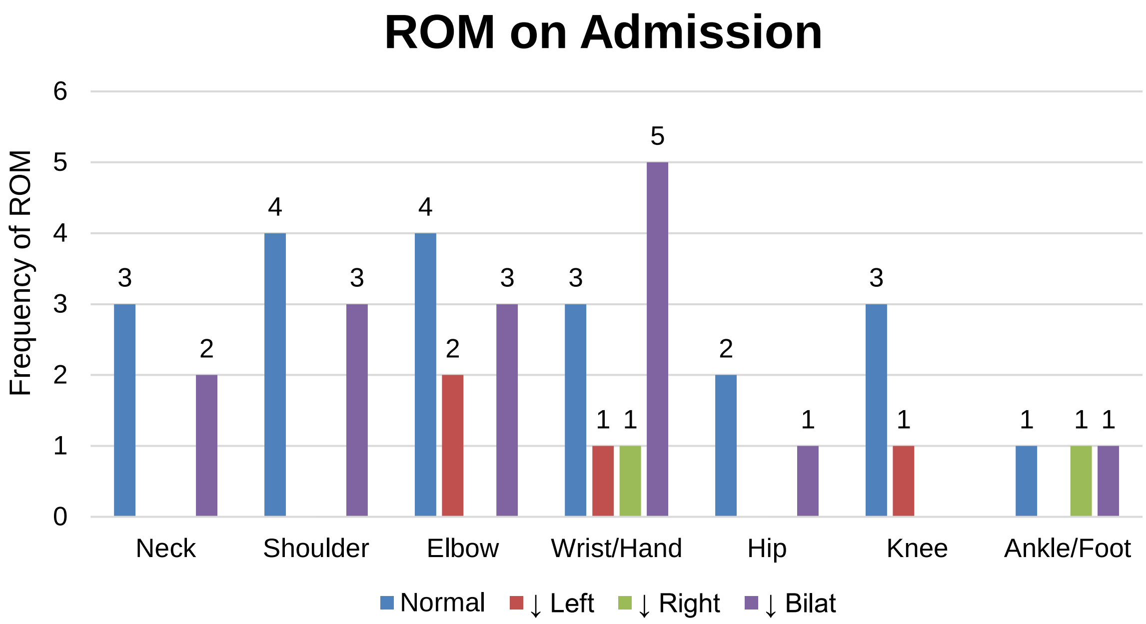
4.2.8 Splinting

Splinting was also an area explored in this study population (n=71). Fifteen patients (21.1%) had splints applied, while splinting was not recorded for 56 patients (78.9%).

4.3 CHANGES IN PHYSICAL FUNCTION

4.3.1 Range of motion

The ROM of the neck, shoulder, elbow, wrist, hand, hip, knee, ankle and foot were recorded. These factors were recorded at hospital admission, ICU discharge and hospital discharge. The following tables present this information.



*Bilat - bilateral ↑ - Increased ↓ - Deceased

Figure 4.7: ROM Recorded on Admission (n=73)

The data were encoded as follows: 1- Unknown/Nil recorded; 2-increased ROM bilaterally; 3-decreased ROM bilaterally; 4-decreased ROM left; 5-decreased ROM right; 6-normal ROM.

The information in this category that could not be found in the patient records amounted to that for 68 (93.2%) patients for the neck ROM, 66 (90.4%) for the shoulder ROM, 64 (87.7%) for the elbow ROM, 63 (86.3%) for the wrist/hand ROM, 70 (95.9%) for the hip ROM, 69 (94.5%) for the knee ROM, and 70 (95.9%) for the ankle/foot ROM.

On admission, the neck ROM was noted as decreased for 2.7% of the cases with 4.1% of the cases having normal neck ROM. The shoulder joint showed that in 4.1% of the cases the ROM was decreased bilaterally, with 5.5% normal. Of the elbow joint ROM, 6.8% of the patients had a decreased ROM, while 5.5% recorded a normal ROM. The hand and wrist had a decreased ROM in 9.6% of the cases, with 4.1% recording a normal ROM. In the lower limb, the first joint recorded was the hip. The normal ROM of the hip was recorded in 2.7% of the patients with a noted 1.4% of them with a decreased ROM bilaterally. The knee ROM on the left was noted as decreased for 1.4% of the patients, while 4.1% of them recorded a normal ROM. Lastly, the foot and ankle were recorded, with 1.4% of the cases with a normal ROM and 2.8% of them showing a decreased ROM (1.4% of the patients had a ROM that was decreased bilaterally and 1.4% had a ROM that was decreased on the right).

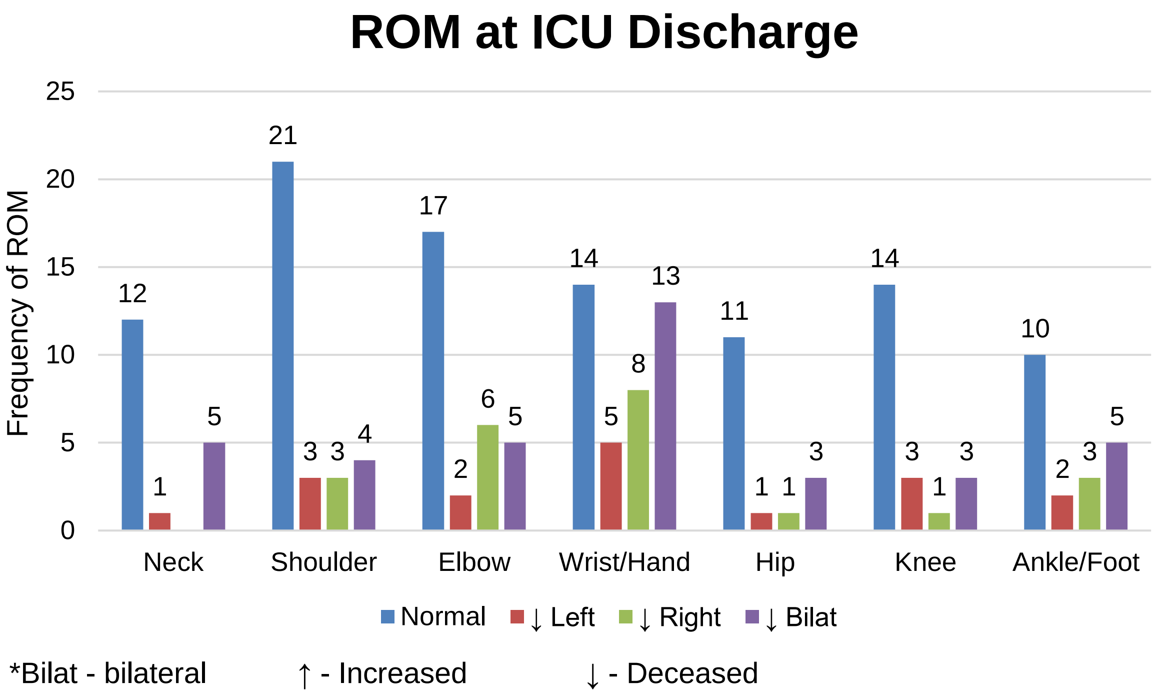
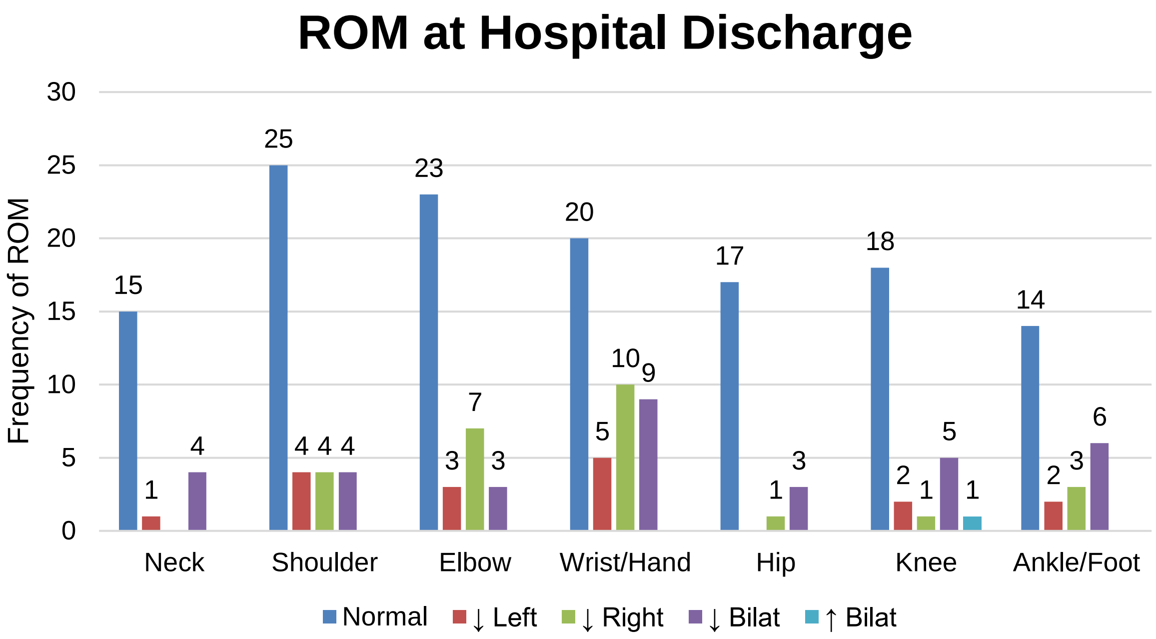


Figure 4.8: ROM Recorded at ICU Discharge (n=73)

At ICU discharge, the information that was not recorded for ROM for the specified joints was as follows: the neck ROM information was missing in 55 (75.3%) patients; with regard to the shoulder ROM, 42 cases (57.5%) were not recorded; for the elbow, the missing ROM information was for 43 cases (58.9%); that for the wrist/hand ROM was for 33 (45.2%) cases; for the hip ROM, there were no records for 57 cases (78.1%); the missing knee ROM information was for 52 cases (71.2%); and for the ankle/foot, no ROM was recorded for 53 (72.6%) of the patients.

On discharge from ICU, the neck showed 8.2% decreased ROM with 16.4% showing normal ROM. The shoulder joint showed that 13.7% of the ROM was decreased with 28.8% normal. For the elbow joint ROM, 17.7% was decreased and 23.3% was recorded as normal. The hand and wrist had decreased ROM in 35.6% of the cases, with19.2% recording a normal ROM. In the lower limb, the first joint recorded was the hip. The normal ROM of the hip was noted in 15.1% of the patients, with 6.9% presenting with decreased ROM. With regard to the knee ROM, 19.2% of the patients recorded normal ROM and 9.6% decreased ROM. Lastly, in the foot and ankle, 13.7% was recorded as normal ROM, with 13.7% of the patients showing decreased ROM. The wrist and hand presented with the largest frequency of decreased ROM at ICU discharge in 35.6% of the patients, while the majority showed decreased ROM in the bilateral category.



*Bilat – bilateral ↑ - Increased ↓ - Deceased

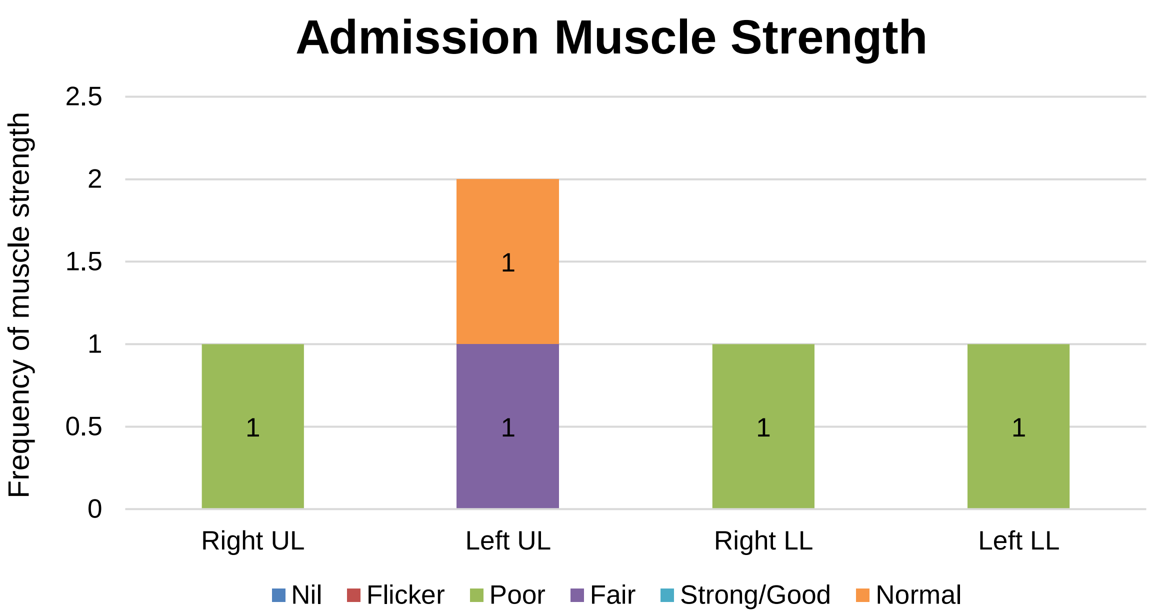
Figure 4.9: ROM Recorded at Hospital Discharge (n=73)

At hospital discharge, the information that was not recorded for the ROM at each joint is as follows: Neck ROM information was missing for 53 (72.6%) patients, while the shoulder ROM in 36 patients (49.3%) was not recorded. For the elbow, the ROM information for 37 of the patients (50.7%) was missing. The wrist/hand ROM was missing for 29 patients (39.7%), while there were no records for the hip ROM in 52 (71.2%) of the patients. On the other hand, the knee ROM for 46 patients (63%) and the ankle/foot ROM for 48 patients (65.8%) were not recorded.

At hospital discharge, the neck showed decreased ROM in 6.9% of the patients while 20.5% of them showed a normal ROM. The shoulder joint ROM in 16.5% of the patients was decreased, while 34.2% of them showed a normal ROM. For the elbow joint 17.8% of the patients showed decreased ROM, while 31.5% recorded a normal ROM. The hand and wrist ROM was decreased in 32.8% of the patients, while 27.4% recorded a normal ROM. In the lower limb, the first joint recorded was the hip. A normal ROM of the hip was recorded in 23.3% of the patients, with 5.5% noted as having a decreased ROM. The knee ROM was noted as decreased in 10.9% of the patients, and 24.7% recorded a normal ROM. Lastly, the ROM of the foot and ankle was recorded. Nineteen-point two percent (19,2%) of the patients recorded a normal ROM and 15.1% of them showed a decreased ROM. Once again, the wrist and hand joints proved to be the more common joints to present with a decreased ROM.

4.3.2 Muscle Strength

The muscle strength for this section was recorded by a health care professional. Figure 4.10 summarises information regarding muscle strength assessment on admission to the Burns Unit.

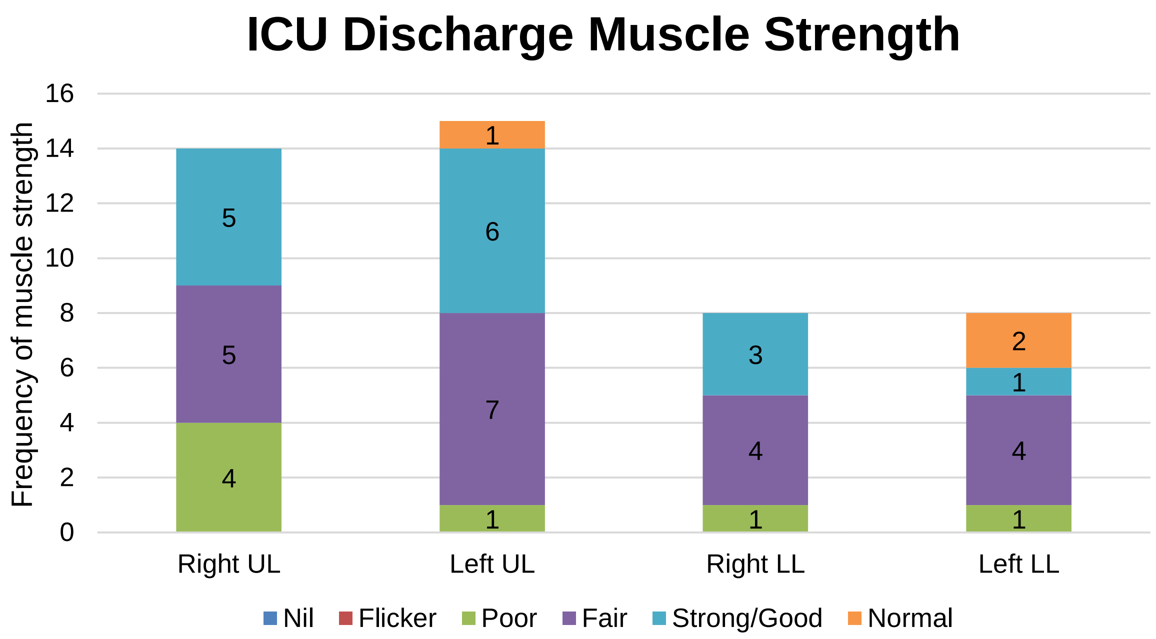


*UL – Upper Limb LL – Lower Limb

Figure 4.10: Muscle Strength Recorded at Admission (n=73)

The right upper limb data for 72 of the patients (98.6%) were not recorded; nor was this the case for the right lower limb and the left lower limb. There were no records for the left upper limb in 71(97.3%) of the patients. It was noted that only one (1.4% of the sample) patient presented with normal strength in the left upper limb. As shown in the graph, the other patients reported poor to fair strength in their respective limbs.

Figure 4.11 summarises the information on the patients' assessment of their muscle strength at their discharge from the Burns ICU.

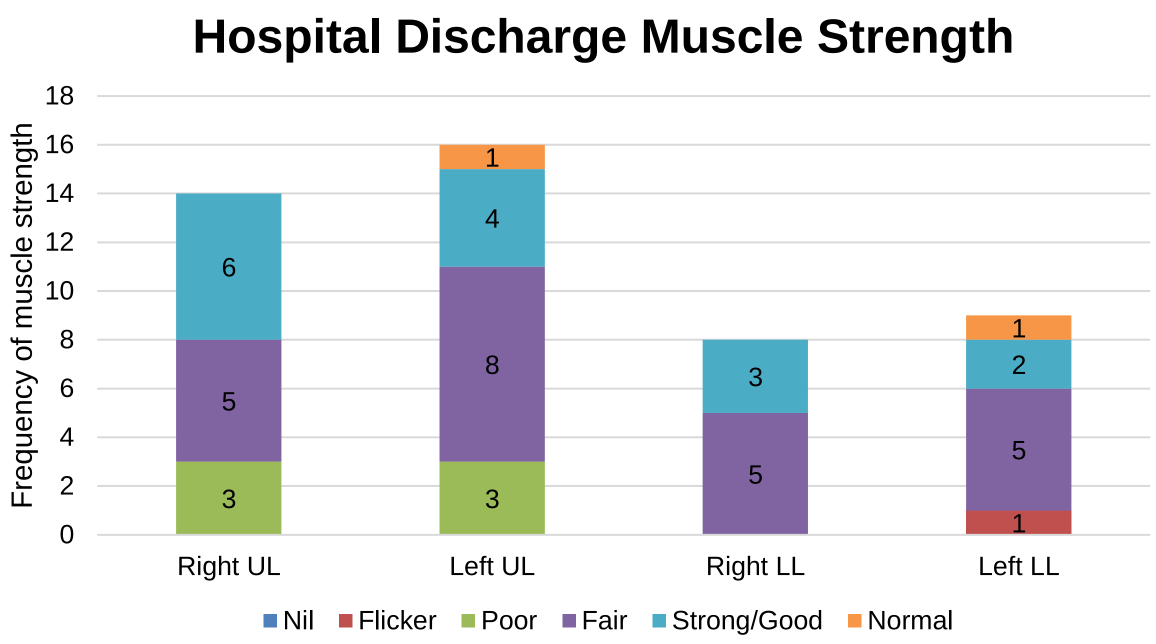


*UL – Upper Limb   LL – Lower Limb

Figure 4.11: Muscle Strength Recorded at ICU Discharge (n=73)

At discharge from the Burns ICU, 59 of the patients (80.8%) did not have records pertaining to the strength of their right upper limb muscles, nor was this the case for 58 of the patients (79.5%) in terms of their left upper limb strength. As for the lower limb, there were no records for 65 of the patients (89%) for the strength of their right lower limb muscles. This was also the case for the muscles of the left lower limb. As represented in the graph above, the muscle strength that was recorded at discharge from the ICU ranged between poor and normal, with the majority of the patients presenting with a fair show of strength in their limbs. Normal muscle strength was noted in one patient (1.4% of the cohort) in the left upper limb and in two (2.7%) patients in the left lower limb.

Figure 4.12 summarises information on the patients' assessment of their muscle strength at the time of their discharge from hospital.



*UL – Upper Limb   LL – Lower Limb

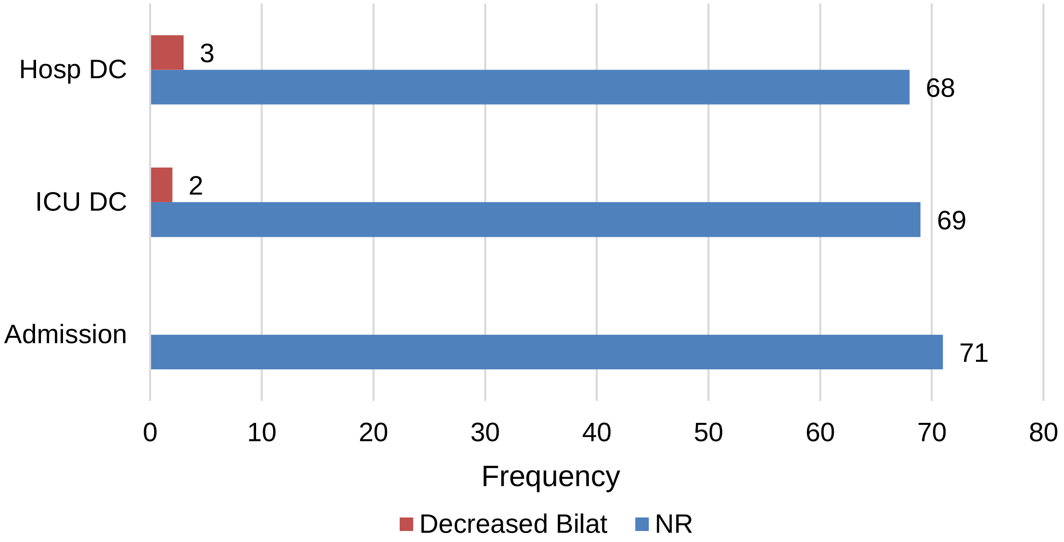
Figure 4.12: Muscle Strength Recorded at Hospital Discharge (n=73)

At hospital discharge, the right upper limb strength was not recorded in 58 of the patients (79.5%); the left upper limb strength was not recorded in 57 of the patients (78.1%); the right lower limb strength was not recorded in 65 of the patients (89%); and the strength of the left lower limb was not recorded in 64 of the patients (87.7%). One of the patients (1.4% of the cohort) had a flicker of strength in the muscles of the left lower limb. As recorded, the muscle strength of the majority of the respondents, however, ranged between poor and strong/good with a resultant assessment of fair muscle strength in most of the recorded data.

4.3.3 Muscle Length

The length of the two-joint muscles was recorded in 71 of the 73 patients. In 25.4% (n=18) of this study population, a decreased two-joint muscle length was noted, with 74.6% (n=53) showing a normal muscle length.

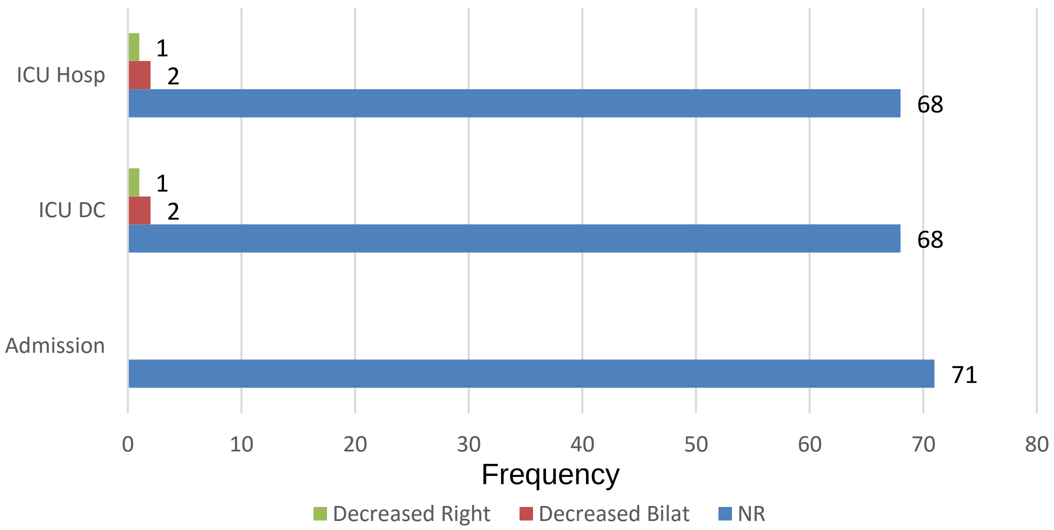
The first of the two-joint muscles explored was the Achilles tendon. At ICU admission, none of the Achilles tendon muscle lengths was recorded. Neither was this measurement recorded for 69 of the patients (97.2% of the cohort) at their discharge from the ICU, only two patients (2.8%) were recorded as having shortened bilateral Achilles tendons and at their discharge from the hospital, three patients (4.2%) were recorded as having bilateral shortening of the Achilles tendons.



*NR - No records Hosp – Hospital DC – Discharge Bilat – Bilateral

Figure 4.13: Achilles Tendon Shortening (n=71)

No records of the reduction of the axillary space for 95.8% (n=68) of the study population were taken at the patients' admission to ICU. At hospital discharge, 2.8% (n=2) of the patients had decreased axillary space bilaterally and 1.4% (n=1) of the patients had a decreased axillary space on the right side (see Fig. 4.14 below).



*NR - No records Hosp – Hospital DC – Discharge Bilat – Bilateral

Figure 4.14: Decreased Axillary Space (n=71)

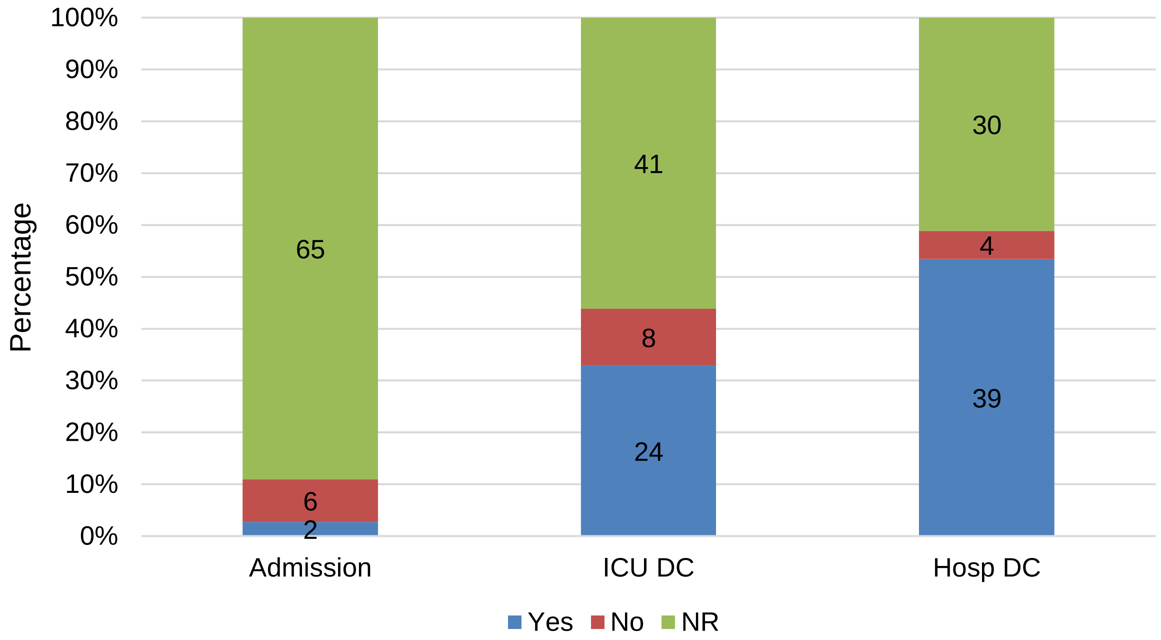
No records were found stating the length of the m. hamstrings, m. quadriceps, wrist extensor, wrist flexor or elbow flexor muscles at admission to ICU. At the time of their discharge from the hospital, one patient (1.4%) presented with decreased bilateral wrist extensor length, and one patient (1.4%) with an increased m. hamstring length. No records for muscle length were found for any of the stated muscles at the time of discharge from ICU.

4.3.4 **Distance Walked**

Of the 73 patients, 61 (83.6%) had no record of any mobilising activity at their admission to ICU. The mean distance walked by the study cohort at ICU discharge was 141.9 (SD: 95.9) metres, with a minimum recorded distance of one metre and a maximum of 358 metres. At hospital discharge, 82.2% (n=60) of the cohort had no walking distance recorded in their files. The mean distance walked in cases where this measurement was captured was 140.7 (SD: 92.1) metres, with a minimum recorded distance of one metre and a maximum of 343 metres.

4.3.5 **Independent Mobilisation and Stair Climbing**

Figure 4.15 below summarises the number of patients in this cohort who were able to mobilise independently at the respective stages of ICU admission, ICU discharge and hospital discharge.



*NR - No records Hosp – Hospital DC – Discharge

Figure 4.15: Representation of Independent Patient Mobilisation (n=73)

From Figure 4.15, it is clear that more than 39 patients in this study cohort (53.4%) for whom information was recorded, were independently mobile at the time of their discharge from hospital.

The patients who were able to climb stairs by the time of their discharge from hospital numbered 21 (28.8%), but no data were recorded for 52 (71.2%) of the patient cohort.

4.3.6 FSS-ICU

At ICU admission, 8.2% (n=6) of the study population (n=73) had a recorded FSS-ICU score. The median FSS-ICU score was 22.5 (IQR: 35). The minimum FSS-ICU score recorded was 0, while the maximum score recorded was 35. At ICU discharge, 52.1% (n=38) of the cohort had records of FSS-ICU data. The median score at ICU discharge was 35 (IQR: 0); the minimum score was 12, and the maximum score was 35. The FSS-ICU at hospital discharge was recorded in 64.4% (n=47) of the cases. The median score was 35 (IQR: 0), while the minimum FSS-ICU score was 22 and the maximum score was 35.

4.4 NUMBER AND TYPE OF COMPLICATIONS DEVELOP

The study cohort developed a median of two complications (IQR: 4) during their hospital stay. The maximum number of complications developed by the patient cohort was 21 and the minimum was 0. Figure 4.16 below summarises the percentage of patients who presented with general complications during assessment.

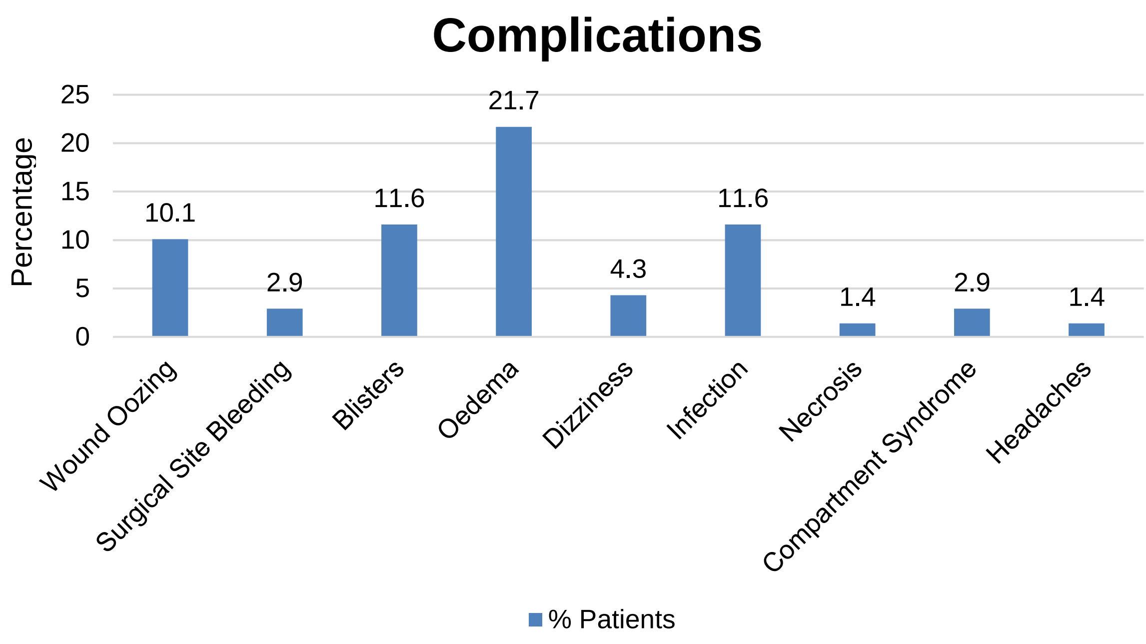
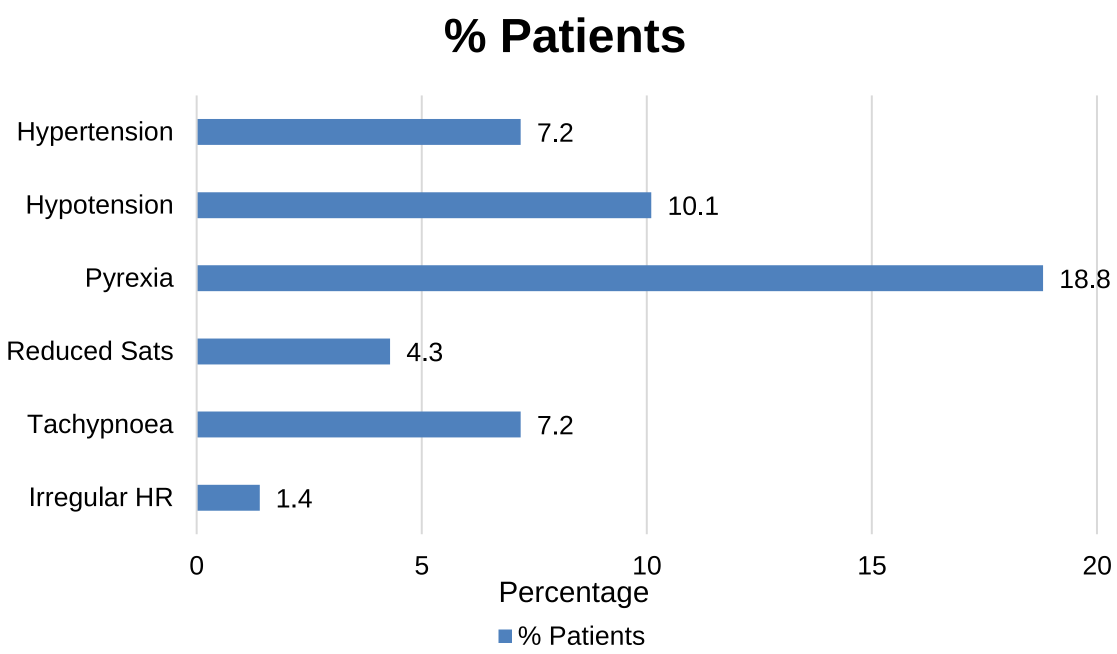


Figure 4.16: Percentage of Patients that Developed General Complications (n=69)

Three general complications were found to predominate during hospital stay, these being oedema (21.7% of the patient cohort), and infection (11.6% of the patient cohort) and blister formation (11.6% of the patient cohort).

Figure 4.17 summarises the percentage of patients who presented with abnormal vital signs during the assessment.



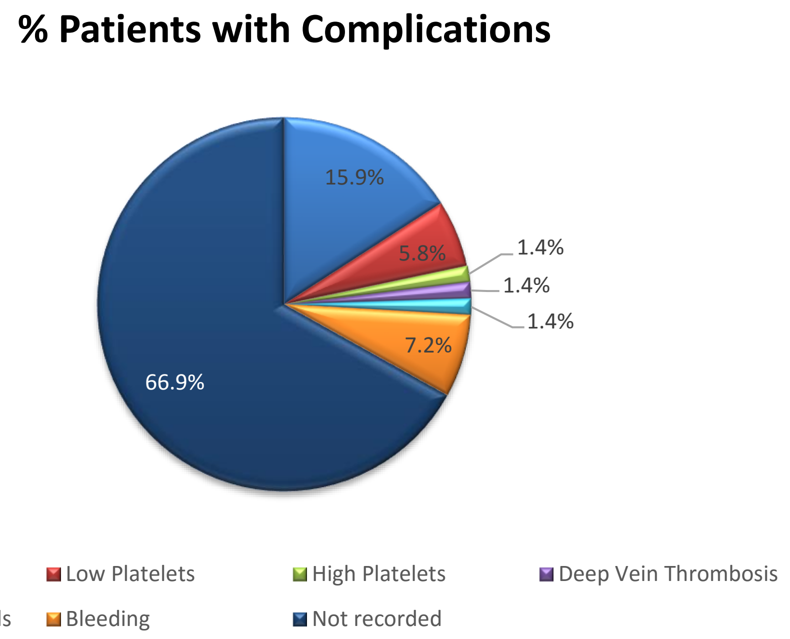
*Sats – Saturation HR - Heart Rate

Figure 4.17: Percentage of Patients with Complications in their Vital Signs (n=69)

Some patients experienced complications in their vital signs. An irregular heart rate did not develop in 52 of the patients (75.4%) and 16 (23.2%) had no recorded data in this respect. Decreased saturation during the hospital stay did not occur in 43 of the patients (62.3%). These data were not recorded in 23 (33.3%) of the patients included in this study. Pyrexia occurred in 13 of the patients (18.8%), while 56 (81.2%) did not experience pyrexia. A low body temperature was not recorded in any of the patients in this study. Hypotension did not occur in 24 (34.8%) of the study population and 38 (55.1%) of the patients had no records on this factor.

Pulmonary complications include pneumonia. Pneumonia was recorded in one of the patients (1.4% of the cohort), 22 (31.9%) did not contract pneumonia and there was no data recorded in this respect for 46 (66.7%) of the patients. Self-extubation occurred in two of the patients (2.9% of the cohort), 14 (20.3%) did not self-extubate and there was no recorded data for 53 (76.8%) of the patients.

Figure 4.18 summarises the number of patients who presented with haematological complications.



*Hb - Haemoglobin

Figure 4.18: Percentage of Patients with Haematological Complications (n=69)

The two most common haematological complications observed were low haemoglobin levels (n=11, 15.9%) and bleeding (n=5, 7.2%). For most patients, no data related to haematological complications were recorded.

Figure 4.19 summarises the percentage of patients who presented with complications of the gastrointestinal tract.

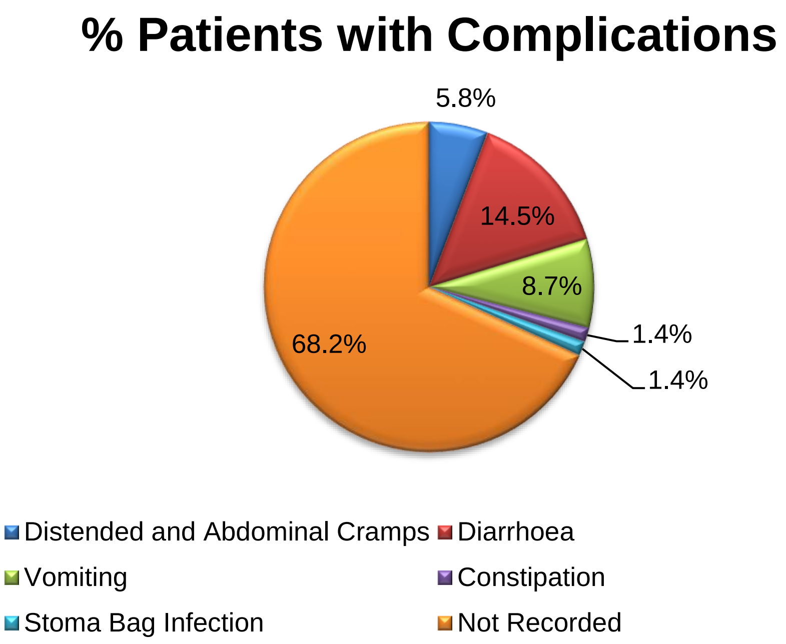


Figure 4.19: Percentage of Patients with Gastrointestinal Complications (n=69)

The three most common complications observed were diarrhoea (n=10, 14.5%), vomiting (n=6, 8.7%), and a distended abdomen with abdominal cramps (n=4, 5.8%). For most of the patients, no data related to gastrointestinal complications were recorded.

Figure 4.20 summarises the percentage of patients who presented with musculoskeletal complications.

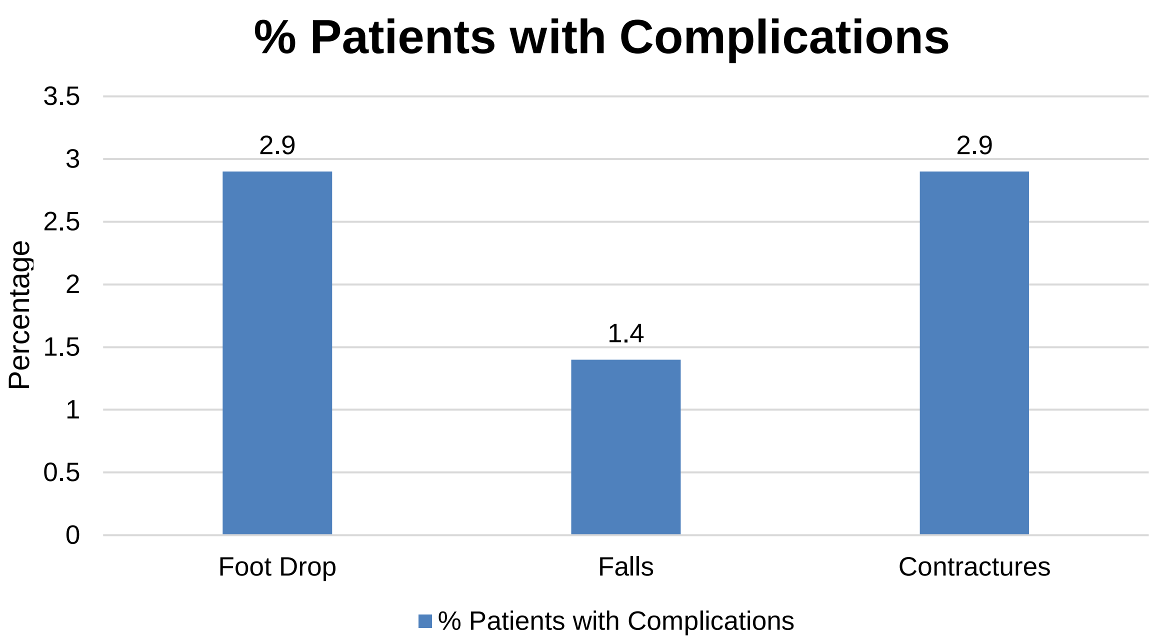


Figure 4.20: Percentage of Patients with Musculoskeletal Complications (n=69)

Foot drop (n=2, 2.9%), and contractures (n=2, 2.9%) were the most prevalent musculoskeletal complications that developed. For most patients, no data related to musculoskeletal complications were recorded.

The neurological complications noted included seizures. One patient (1.4% of the cohort) experienced seizures, 29 (42%) did not, and there were no records for 39 (56.5%) of the patients. Three of the patients (4,3% of the cohort) experienced decreased sensation, 18.8% (n=13) did not, and there were no records for 76.8% of the cohort (n=53). Rigors were found in only one patient (1.4% of the cohort), 29 (42%) recorded not having experienced rigors, while there were no records regarding rigors for 39 (56.5%) of the patients.

4.5 RESPECTIVE ASSOCIATIONS BETWEEN ISS, ICU LOS, HOSPITAL LOS, NUMBER OF THEATRE VISITS, AND NUMBER OF COMPLICATIONS DEVELOPED AND NON-INDEPENDENT PHYSICAL FUNCTION (FSS-ICU<35) OF PATIENTS AT HOSPITAL DISCHARGE

A binary logistic regression analysis was applied to determine the odds ratio as to whether the ISS, ICU LOS, hospital LOS, number of theatre visits, and number of complications developed, influenced non-independent physical function (FSS-ICU=35) at discharge from hospital.

4.5.1 Severity of Injury and Physical Function at Hospital Discharge

For the association between the severity of injury (ISS) and physical function at hospital discharge, the p-value was found to be insignificant (p-value=0.136). Therefore, the odds ratio (Exp (B)) is not applicable (see table 4.2). As such, it was found that there is no association between the severity of the burn injury (ISS) and non-independent physical function (FSS-ICU<35) at hospital discharge.

Table 4.2: Severity of Injury and Physical Function (n=73)

	B	**S.E.**	**Wald**	**Df**	**Sig.**	**Exp(B)**
ISS	.102	.068	2.222	1	.136	1.107
Constant	-4.158	1.609	6.677	1	.010	.016

B – coefficient for the constant in the null model
S.E. – standard error around the coefficient for the constant
Wald – Wald chi-square test, tests the null hypothesis that the constant = 0
df – degrees of freedom for the Wald chi-square test
Sig. – Significance
Exp(B) – exponentiation of the B coefficient, it is an odds ratio

4.5.2 Complications Developed in ICU and Physical Function at Hospital Discharge

For the association between the number of complications developed in the ICU and non-independent physical function (FSS-ICU<35) at hospital discharge, the p-value was found to be insignificant (p-value=0.644) and therefore the odds ratio (Exp (B)) is not applicable (see table 4.3). As such, it was found that there is no association between complications developed in the ICU and non-independent physical function at hospital discharge.

Table 4.3: Number of Complications Developed and Physical Function (n=70)

	B	**S.E.**	**Wald**	**Df**	**Sig.**	**Exp(B)**
No of Complications	.042	.091	.213	1	.644	1.043
Constant	-2.291	.648	12.489	1	.000	.101

B – coefficient for the constant in the null model
S.E. – standard error around the coefficient for the constant
Wald – Wald chi-square test, tests the null hypothesis that the constant = 0
df – degrees of freedom for the Wald chi-square test
Sig. – Significance
Exp(B) – exponentiation of the B coefficient, it is an odds ratio

4.5.3 Number of Surgical Procedures Performed and Physical Function at Hospital Discharge

For the association between the number of surgical procedures performed and non-independent physical function (FSS-ICU<35) at hospital discharge, the p-value was found to be insignificant (p-value=0.324) and therefore the odds ratio (Exp (B)) is not applicable (see table 4.4). As such, it was found that there is no association between the number of surgical procedures in theatre that participants undergo and non-independent physical function at hospital discharge.

Table 4.4: Number of Surgical Procedures and Physical Function (n=73)

	B	**S.E.**	**Wald**	**Df**	**Sig.**	**Exp(B)**
Theatre Visits	.056	.057	.972	1	.324	1.057
Constant	-2.680	.796	11.334	1	.001	.069

B – coefficient for the constant in the null model
S.E. – standard error around the coefficient for the constant
Wald – Wald chi-square test, tests the null hypothesis that the constant = 0
df – degrees of freedom for the Wald chi-square test
Sig. – Significance
Exp(B) – exponentiation of the B coefficient, it is an odds ratio

4.5.4 Hospital and ICU Length of Stay and Physical Function at Hospital Discharge

For the association between hospital LOS and non-independent physical function (FSS-ICU<35) at hospital discharge, the p-value was found to be insignificant (p-value=0.539) and therefore the odds ratio (Exp (B)) was not applicable (see table 4.5). Therefore, there was no association found between hospital LOS and non-independent physical function at hospital discharge.

Table 4.5: Hospital Length of Stay and Physical Function (n=73)

	B	S.E.	Wald	Df	Sig.	Exp(B)
Hosp LOS	-.009	.015	.378	1	.539	.991
Constant	-1.654	.844	3.844	1	.050	.191

B – coefficient for the constant in the null model
S.E. – standard error around the coefficient for the constant
Wald – Wald chi-square test, tests the null hypothesis that the constant = 0
df – degrees of freedom for the Wald chi-square test
Sig. – Significance
Exp(B) – exponentiation of the B coefficient, it is an odds ratio

For the association between ICU LOS and non-independent physical function (FSS-ICU<35) at hospital discharge, the p-value was found to be insignificant (p-value=0.791). As such, the odds ratio was not considered (see table 4.6). Therefore, the ICU LOS is not associated with non-independent physical function at hospital discharge.

Table 4.6: ICU Length of Stay and Physical Function (n=73)

	B	S.E.	Wald	Df	Sig.	Exp(B)
ICU LOS	.007	.025	.070	1	.791	1.007
Constant	-2.266	.722	9.856	1	.002	.104

B – coefficient for the constant in the null model
S.E. – standard error around the coefficient for the constant
Wald – Wald chi-square test, tests the null hypothesis that the constant = 0
df – degrees of freedom for the Wald chi-square test
Sig. – Significance
Exp(B) – exponentiation of the B coefficient, it is an odds ratio

4.6 SUMMARY OF RESULTS

There were many results pertaining to this study cohort. A total of 84 patients were admitted to the hospital. Of these 84, 73 fitted the inclusion criteria. Most of the patients were male, of black ethnicity, and with a median age of 38. The most frequent mechanism of injury was of a thermal nature. It was found that the median total body surface area that was burned was 31%, with the upper limbs being the most common to sustain injury. The median ISS was 16 and the mean revised Baux score was 93. The LOS ranged from seven days to a maximum of 243. The total number of surgeries that a patient underwent amounted to 29. The most common surgery was a debridement. Of the study cohort, 43.8% of the patients were intubated and ventilated and 45.2% needed sedation. The range of motion was noted to be the most decreased in the hands bilaterally. The collective ROM seemed to improve over the hospital stay, as was the case with muscle strength. The muscle length of the Achilles tendon was the most common of the two-joint muscles to have shortened. The distance walked, independent mobilisation, stair climbing, and the FSS-ICU score, seemed to improve throughout the hospital stay. The most common complication with 21.7% of the patient cohort, was oedema. No associations were found between ISS, ICU LOS, the number of theatre visits, and the number of complications developed respectively and non-independent physical function.

CHAPTER 5

5. DISCUSSION

This section interprets the results presented in the previous section. Included in this section are the limitations that were found in this study as well as the recommendations for future research.

5.1 DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF STUDY COHORT

The current cohort of patients presenting with major burn injury were predominantly of black ethnicity. As the median age showed 38 years, it can be said that half of the study population were either 38 years of age or older. In Australia, Paratz et al. (2012) noted in their study that the average age of a thermal burn injury victim was 34.3 years of age. In our study, the age group tended towards the older age group. Den Hollander et al. (2014) noted in a hospital in Durban, that of the patients with burn injuries that were admitted to hospital, 42% were adults with a mean age of 30 years. In this study population, it was noted that 94% of the patients admitted to the Burns Unit with major burn injuries were adult and that most of them were males. This correlates with a higher rate of burns in males, as observed in similar studies in the United States of America and in Durban, South Africa (Mason et al. 2012; den Hollander et al. 2014).

In this study cohort, the main cause of major burns was thermal injury and approximately a quarter of the patients (23.3%) presented with inhalation injury. In Durban, 81.2% of the major burns were caused by flames and 13.6% were associated with an inhalation injury (den Hollander et al. 2014). In the United States of America, the most common mechanism of injury was found to be thermal burns (Mason, et al. 2012). In the Western Cape, Maritz (2012) stated that 21% of the admissions to the hospital that this study researched were due to injuries sustained from fuel stoves and fires in shacks. Maritz (2012) continued to claim that 71% of the burns were due to the use of kerosene stoves and 24% resulted from the use of gas stoves. Den Hollander et al. (2014) stated that their statistics were comparable to other burns units in South Africa. A comparison of the results from this study with others conducted in South Africa serves to confirm this statement.

The differences noted in the statistics from this particular study cohort include the larger percentage of inhalation injuries, as well as the fact that the majority of the patients admitted to the Burns Unit were adults.

As previously discussed, a major burn injury can be defined as a burn injury to 20% or more of the total body surface area (excluding superficial burns), and with more than five percent of the burns being full thickness injuries, and being further compounded by major trauma or inhalation injury (Hettiaratchy and Papini, 2004; Borke, Zieve and Ogilvie, 2016; Gauglitz and Williams, 2016). Twenty-six percent (26%) of the study population had the depth of their injury recorded. Full thickness burns were seen in 12.3% of the patient cohort. It can therefore be deduced that with only 23.3% of the patients having records of the depth of their injury from the burn, according to the definition mentioned above, the remaining 76.7% of the study cohort would have sustained burns to at least 20% of their total body surface area, with five percent of the 20% being full thickness burns, as the patients included in this study were classified as patients with major burn injuries.

In this study cohort, the top three areas that tend to be affected most frequently from burns include the upper limbs and head, followed by the lower limbs. Forjuoh (2006) stated that the variety, in terms of the type and extent of the burn injuries, were noted to mainly affect the upper limbs (except in the case of flame burns), and subsequently the lower limbs in low-to middle-income countries. Not many studies report on the location of a burn, but it has been noted that the burning of the victims' clothing principally affects the lower limbs (Forjuoh, 2006). The areas burned in this study cohort could be attributed to the most common mechanism of injury, namely thermal injury. In South Africa, fires are used for cooking, as sources of heat and lighting, and for social gatherings, and in most burns cases, the injury through fire has been found to be unintentional (Forjuoh, 2006; Hanekom, et al. 2015; WHO, 2019a). As people, in making and working with fires, use their hands, in the event of an accident, it would be the most likely hypothesis that the upper limbs and head would be the top two most common areas to be burned. As mentioned above, the lower limbs may be affected when clothing catches alight and also possibly when an explosion or the spilling of flammable substances occurs.

As the majority of the participants in the study cohort were males, of black ethnicity, and the most common areas burned were the limbs, these burns could be linked to injuries on duty as burn injuries have been seen to occur at work (e.g. when people work with flammable substance) and it has been noted that work-related injuries predominantly involve the extremities (Forjuoh, 2006; Hanekom et al. 2015; WHO, 2019a).

Half of this study population were found to have sustained burn injuries to 31% or more and a maximum of 77%, of their total body surface area (TBSA), and all of these patients had survived their hospital stay. The other half scored a TBSA affected by burns of between 20% and 31%. According to the Rule of Nines, and the most common areas in this patient cohort to have been burned, correlations can be seen in terms of the TBSA percentages noted above and the risk of mortality. Patients with below 10% of their total body surface area burned had a low mortality risk, as opposed to patients with above 50% of their TBSA burned, who presented with a high risk of mortality (Forjuoh, 2006).

It was noted in another study of 24 males (Paratz et al. 2012), that the average for the total area of the body surface burned amounted to 42.9%, which is more than what was noted in our study. A study conducted in Durban noted an overall mortality of 15.1%, mostly in patients with burns that affected more than 30% of their total body surface area (den Hollander et al. 2014).

Patients with burn injuries affecting more than 60% of their TBSA experienced moderate to severe problems in their mobility; they experienced anxiety or depression, pain and discomfort, and had to deal with challenges in terms of self-care and their usual ADLs (Tirumala et al. 2013). On the other hand, those with burns sustained to less than 19% of their total body surface area presented with relatively mild problems in all of the areas mentioned within the period six months subsequent to their discharge from hospital (Tirumala et al. 2013). Therefore, it is important to be informed about the total body surface area percentage burned including adverse effects stemming from this event in order for these effects to be mitigated as soon as possible.

As mentioned previously, an Injury Severity Score (ISS) of 15 or more in a major trauma is associated with a 10% risk of mortality (Palmer, 2007; Karadsheh and Taylor, 2018). As the median in this study population was found to be 16, it can be said that half of the patients presented with a risk of mortality of less than 10%. As the ISS rises, so the risk of mortality also rises, however, it is important to remember, none of the patients included in this cohort died.

A mortality of more than 50% of a cohort was found in a study for burn patients with a Baux score greater than 80 (only one patient with a Baux score of more than 100 survived) (den Hollander et al. 2014). A 50% chance of mortality was found to be true for those burn victims who scored over 75 in the revised Baux score in the study by Smith, Allorto and Clarke (2016). In this study population, the revised Baux score averaged at 93, while the original Baux score averaged 78.5. In terms of the information mentioned above, this could be interpreted to mean that the majority of the study population are at risk of mortality, and that at least 50% will potentially need some form of palliative care.

In this study cohort, the hospital LOS stood at a minimum of seven days. As this is a study focusing on major burn injuries, it may be hypothesized that the patient in question with such a short LOS, might have sustained burns in less compromising areas than other patients. On the other hand, the maximum hospital LOS was noted to be 243 days. The patient with the longest LOS featured as a statistical outlier in the regression analysis, and not as the norm. He/she had an injury severity score of 29, with a total of 27 visits to the theatre and 17 complications recorded (hallucinations, subluxed joints, contracture, infection, oedema, abdominal cramps, vomiting, diarrhoea, decreased haemoglobin levels, pyrexia, raised blood pressure, tachypnoea, tachycardia, decreased saturation). This extended LOS, allowing for rehabilitation in the hospital and healing after the surgeries (e.g. skin grafts) and the mentioned complications, as explained above, is more of an exception to the rule. The more realistic measure would be the median hospital LOS, which was recorded at 44 days. This means that half of the patients spent 44 days or more in hospital.

With regard to the ICU LOS, the minimum and maximum LOSs were recorded as 0 and 81 days respectively, with a median of 17 days. It is unclear as to whether the patient was admitted to ICU and transferred the same day to High Care or the Burns ward (High Care and the Burns ward were collated as one) in order to get an ICU LOS minimum at zero. Den Hollander et al. (2014) reported an average hospital LOS of 22.8 days in a study population of varying burn injury severities in Durban. In another study conducted in a South African regional hospital, burns patients (without other trauma, or with other trauma) endured a hospital LOS average of 9.1 days (Pape, Swart and Duvenage, 2019). This amounted to a shorter period in hospital for the patients in this study cohort.

Van der Merwe (2008) noted that for every percent of the total body surface area burned, approximately one day is added to the average length of stay (LOS) in the Burns ICU (one day per percentage of the TBSA burned). With regard to this study, this notion seems reasonable as the TBSA burned was found to range between 20% and 77%, the ICU length of stay to range from 0 to 81 days, and half of the study cohort had an ICU LOS of 17 days or more.

This study cohort had a median of six surgeries which means that half of the patients had a total of six surgeries or more. The maximum number of surgeries a patient in this study population received was 29. This would affect the patient's LOS at the hospital. In descending order, the top four surgeries included would be debridement, skin grafts, theatre dressings and the insertion of a tracheostomy. This information suggests that the primary cause of surgery is wound management.

Jang, Joo and Seo (2018) noted that 38.9% of patients with burn injuries are forced to undergo major amputations and 61.1% minor amputations. In this study cohort, only two (2.7%) of the patients underwent an amputation.

The patients in this study who needed intubation and mechanical ventilation numbered 32 (43.8%). Two of them (2.9% of the patient cohort) self-extubated in this study but it is unclear whether they were the patients that needed to be re-intubated. Three patients (4.1%) required re-intubation and of the 73 patients, 33 (45.2%) were sedated. As the fourth-leading surgical procedure in this study cohort, the insertion of a tracheostomy (n=16, 22%) suggests that of the mechanically-ventilated patients, 50% were ventilated for longer than two weeks.

As such, this could be interpreted as a situation where respiratory compromise would prevail and where a tracheostomy would be necessary. It should also be noted that as discussed in the literature review, and as a result of burn injury and critical illness, the patients may present with increased complications, cachexia and muscle weakness (not limited to but also including respiratory muscle weakness), which would lead to an extended mechanical ventilator weaning period and thus result in a need for a tracheostomy.

Tracheostomies are common in patients with recurrent surgeries and burns to the neck, which was the fifth most common area burned in this study cohort, and the head, the second most common area burned in this study cohort (Aggarwal, Smailes and Dziewulski, 2009; Depetris et al. 2015). A tracheostomy enhances the comfort and safety of the patient, reduces the need for sedation, and the resistance to airflow, and thus assists in the weaning of the patient off a ventilator. As such, a tracheostomy ensures a shorter LOS in hospital (Durbin, 2010; Hanekom et al. 2015).

Sedation is usually necessary for patient comfort in an ICU clinical setting, which is largely needed in this patient population to foster pain management arising from the patients' injuries and particularly after painful surgeries (e.g. debridement). The greater need for sedation in this study cohort, could impact the length of the period of mechanical ventilation and intubation, and therefore the need for a tracheostomy.

The independent risk factors associated with extubation failure in a trauma population include initial airway intubation, a low extubation Glasgow Coma Scale (GCS) and a spinal fracture (Brown et al. 2011). The most common cause of re-intubation is respiratory failure (Brown et al. 2011). Those who fail extubation have been seen to have an increased LOS in ICU and the hospital (Brown et al. 2011). Other risk factors for re-intubation include self-extubation, delirium, increased age, opioid (enteral use), and moderate and copious secretions (Michetti et al. 2018; Mahmood et al. 2019). One study recorded failed extubation at six percent (6%), with another study recording a 7.9% need for re-intubation, and a third study reporting a 30.7% level of re-intubation, all three reporting a higher incidence of re-intubation than was found in this study cohort, namely 4.1% (Brown et al. 2011; Michetti et al. 2018; Mahmood et al. 2019). The higher recorded re-intubation in the other studies mentioned above might have been due to a larger sample size.

Splinting was used for 21.1% of the study population. It is interesting that in a population that sustained major burn injuries only 15 patients needed splinting. There was missing information regarding splinting in the patient records. Thus, it is difficult to state why the splinting was used (e.g. to prevent the shortening of muscles and to improve muscle length) and for which joints it was used. To the knowledge of the researcher and according to the physiotherapy notes retrieved for this study cohort, none of the patients used an Unna boot nor elastic bandage wraps for mobilisation.

5.2 CHANGES IN PHYSICAL FUNCTION

On admission and at ICU discharge, the joint with the most decreased ROM was the wrist and hands bilaterally. This could be interpreted in terms of the fact that the patients had sustained major burn injuries whilst handling an agent that could cause burns. In this study cohort, the most prevalent cause of a burn was from a thermal or an electrical source. Thermal burn injuries could be due to the spilling of hot liquids, or inadvertently start an uncontrollable fire or cause an explosion. Other possibilities could be the picking up of hot solid objects or a body part that might come close to a steam source. This supports the fact that the wrists and hands are more susceptible to burning as one would use the wrist and hands to carry a hot object, a hot liquid or to start a fire.

Electrical burns might arise from working with electrical appliances while not taking the appropriate precautions (e.g. switching off the electrical main). In South Africa, as mentioned in the literature review, electrical burns are possibly predominantly caused through the theft of electrical cables (Padilha, Muganza and Candy, 2016). One of the classifications for an electrical burn is a contact injury and may be another reason why the hands and wrists are affected more predominantly. The injuries sustained may affect the ROM of the joints involved.

At ICU discharge, decreased neck ROM was reported for six (8.2%) patients. Five patients presented with decreased ankle and foot ROM bilaterally (6.8%). The altered ROM in the ankle and foot might affect the ability of the patient to mobilise. This will be discussed at a later stage.

At hospital discharge, an increase in the ROM of all joints studied was recorded, but with the exception of the ROM of the wrist and hand. The increase in the joint ROM might be due to the therapy carried out with the study population during hospitalisation. The hand is a complex structure, thus regaining normal ROM after a burn injury might be difficult. It was also noted that there was a reduction in the ROM of the knees, ankles and feet at hospital discharge. The possible reasons for the decreased ROM over the period from ICU discharge to hospital discharge might be due to the lack of patient compliance, the need for joint immobility, and for multiple surgeries.

Schneider et al. (2006) noted that the most common joints affected by the formation of contractures involve the shoulder, elbow and knee. Predictors that were noted to affect contracture formation included the LOS, skin grafts, and the extent of the burn injury (Schneider et al. 2006). In this study, the ROM of the hand and wrist was the most affected and this could be the cause of the contractures. It is, therefore, important within the acute hospital stay to initiate aggressive physiotherapy, as well as therapeutic positioning, as soon as possible (Schneider et al. 2006).

On account of catabolism, as well as the bed-rest that the patient is placed on, the muscle strength in patients with major burn injuries loses condition (de Lateur et al. 2007). Owing to the hypermetabolic state, the catabolism can persist for six months to several years subsequent to the healing of the wound (Hettiaratchy and Dziewulski, 2004; de Lateur et al. 2007; Hanekom et al. 2015; Greenhalgh, 2017; Nielson et al. 2017). The patient could also present with critical illness-induced muscle wasting, including the loss of muscle mass (Nielson et al. 2017).

On admission to hospital, little information was recorded in the patients' notes about their muscle strength. Possible reasons for this might be that the patient was sedated, with the result that the therapist would not have been able to successfully check the patient's muscle strength. Other reasons might have been due to reduced patient compliance, as well as the instability of the patient, which would have precluded an initial assessment.

Once again, at ICU discharge, limited information was recorded in the patients' notes on changes in the muscle strength of their upper and lower limbs. For those who did have records, it was evident that they presented with fair strength in their upper and lower limbs at ICU discharge.

At hospital discharge, more patients had information pertaining to muscle strength captured in their records. These patients presented with fair to good muscle strength in their upper and lower extremities. The muscle weakness in these cases could be attributed to catabolism and the muscle wasting mentioned above. Ahmed et al. (2011) noted that a structured exercise programme, specifically isokinetic training, would improve eccentric and concentric muscle strength. As all patients were subjected to physiotherapy management during their hospital stay, it is reasonable to conclude that they responded clinically to the rehabilitation received.

Even with aggressive physiotherapy, joint problems (contractures, hypertrophic scarring) and the shortening of the two-joint muscles were anticipated with deep partial thickness burns (Hanekom et al. 2015). Limited information was captured in patients' records on the length of their two-joint muscles. For those who did have recorded information, some presented with shortened Achilles tendons and axillary web spaces, shortened wrist extensors, and lengthened m. hamstrings. As this study cohort had sustained major burn injuries, it is not surprising that some presented with limited muscle length at the time of hospital discharge. These patients might be at risk of contracture formation subsequent to their discharge from hospital as contractures generally form in many of the flexor surfaces and in the axilla (Hanekom et al. 2015). They would therefore benefit from continued rehabilitation services for up to months or even years after discharge (Wiechman and Patterson, 2004; Spires et al. 2007; Procter, 2010; Hanekom et al. 2015).

At ICU discharge, the patients in the cohort walked an average distance of 141.9 metres, and the distance walked at the time of hospital discharge was similar (140.7 meters). Paratz et al. (2012) used high-intensity exercise training (aerobic and resistance exercises) in their therapies for their cohort of patients with major burn injury. As a result, their patients were able to increase the distance walked from 168 metres to 459 metres for the period extending from ICU discharge to hospital discharge (Paratz et al. 2012).

The distance walked by the current cohort was significantly shorter at hospital discharge than that of the study by Paratz et al. (2012) described above. A possible explanation for this finding is that for some patients the distances walked at the stage that they were discharged from hospital were not recorded in their notes. It could be that these patients were mobilising independently at the time and might have been discharged from physiotherapy care prior to their discharge from the hospital.

At hospital discharge, more than half of the cohort were functionally independent (median FSS-ICU score of 35/35) and 21 patients were able to climb stairs. As the patients became more functional, the use of the FSS-ICU score became more feasible and thus an increase in the usage of FSS-ICU score was noted from hospital admission to discharge. As mentioned previously, Thrush et al. (2012) found the FSS-ICU to appropriately monitor the functional progression of patients in a hospital for longer term acute care. The FSS-ICU is a good tool to monitor a patient's progression as it is receptive to change in function (Parry et al. 2015; Huang et al. 2016). Choo et al. (2006) noted by using the Functional Independence Measure (FIM) that 47.2% of their cohort were independent enough to go home and 52.8% were discharged to step down facilities. In this study cohort, more than half the patients were found to be independent in function at hospital discharge. From the period extending from ICU admission to hospital discharge, there was a decline in the needs of the patient in terms of care (Corner et al. 2015). The above statement supports the notion that the ability of this cohort to perform functional tasks independently improved steadily throughout their hospital stay since they were receiving needs-based physiotherapy care.

Burn injuries affect and are likely to impair the QOL of the survivors (Forjuoh, 2006; Smolle et al. 2017; WHO, 2019a). It is important that these patients should attain independent function at the time of their discharge from hospital to optimise their recovery trajectory and their perceived QOL.

5.3 NUMBER AND TYPE OF COMPLICATIONS DEVELOPED

Half of the patients in this study cohort had either two complications or more as a result of the burns which they had sustained. The most common complications were oedema, pyrexia, low haemoglobin, diarrhoea, blisters and infection. Oedema may be due to IV fluid overload, increased capillary permeability as well as blood flow slowing in that area. Oedema (inflammation) arises on account of disturbances to the cellular membrane and capillary membrane leaks (Devgan, 2006; Hettiaratchy and Dziewulski, 2004; Devgan, 2006; Orgill, 2009; Nielson et al. 2017; Strudwick and Cowin, 2018). In several studies, it has been noted that exaggerated generalized and local tissue oedema occur in response to a burn injury (Infanger et al 2004; Edgar et al. 2011; Kenworthy et al. 2017). The median for the TBSA burned in this study cohort was 31%. Inflammatory mediators cause a systemic effect, causing oedema to be one of the complications that develop, reaching 21.7% (the leading complication) of this patient cohort.

Pyrexia may be due to the disturbance in thermoregulation that accompanies major burn injuries including the increased metabolic response, systemic inflammation, or the development of an infection. The low haemoglobin and platelet levels might be due to blood loss through the wounds sustained at the time of injury, through the multiple debridement procedures as part of the wound care regime, and through the phlebotomy procedures performed in the ICU. The reason for vomiting (8.7%) and diarrhoea (14.5%) could be due to the medication given to the patients in the Burns Unit (e.g. opioids cause vomiting and constipation, and antibiotics cause diarrhoea). The fifth leading complication in the study cohort is blisters, which develop in partial thickness burns (superficial and deep), therefore, is expected to be and is one of the leading complications. Tied in the fifth leading complication is the occurrence of infections which can be due to necrotic debris (allow bacterial growth) or immunosuppression (as discussed in section 2.8.1). In a burn that covers a total body surface area equal to or greater than 30%, a systemic effect is caused by the release of inflammatory mediators (Hettiaratchy and Dziewulski, 2004).

The systemic changes have been noted, with a TBSA burns of 30% or more, to include cardiovascular (systemic hypotension), metabolic (decreased gut integrity, catabolism) and respiratory system changes (Hettiaratchy and Dziewulski, 2004; Orgill, 2009). In connection with this statement, this study cohort, with a median TBSA of 31%, noted a total of 18.7% cardiovascular complications (hypotension, hypertension, irregular heart rate); 30,4% metabolic complications (diarrhoea, vomiting, abdominal distension, abdominal cramps, constipation); and 15.8% respiratory complications (tachypnoea, decreased oxygen saturation, pneumonia, self-exubation). Other complications that were recorded for this cohort included bleeding, vomiting, hypotension, dizziness and wound oozing.

Leblebici et al. (2006) noted a prevalence of contractures in burn patients ranging from 28%-42%, whereas, Oosterwijk et al, (2017) reported scar contractures in a range between 38%-54%. Another study measured the prevalence of a burns scar contractures between patients treated with pressure and splints, and those treated without (Ferguson et al. 2007). Those treated with pressure and splints (less than 6 months) found contractures in 89.9% (axilla), 70% (elbow), 68.8% (wrist), and 50% (knee) of their study cohort, however, those treated without pressure and splinting presented with contractures in 94.8% (axilla), 81.5% (elbow), 62.9% (wrist), and 74.6% (knee) (Ferguson et al. 2007). In this study cohort, two patients (2.9% of the cohort) presented with drop foot and two (2.9%) presented with contractures. Owing to the severity of their burn injuries, one would anticipate more musculoskeletal complications to be present in this study cohort. One explanation could be the lack of data capturing in the patients' records. Another reason for the limited number of musculoskeletal complications could be the quality of preventative physiotherapy that patients received during their hospital stay.

5.4 ASSOCIATIONS BETWEEN INJURY SEVERITY, ICU AND HOSPITAL LOS, NUMBER OF THEATRE VISITS, AND NUMBER OF COMPLICATIONS DEVELOPED DURING HOSPITALISATION RESPECTIVELY, AND LEVEL OF PHYSICAL FUNCTION OF PATIENTS AT HOSPITAL DISCHARGE

The median Injury Severity Score for this cohort of patients (ISS=16) was considered to be indicative of the level of injury. There was no association found in this cohort of patients between their ISS and their level of non-independent physical function at hospital discharge. The ISS serves predominantly as an indication that is predictive of mortality but it can also help to determine the expected LOS of patients in hospital, the duration of their disability, their discharge destination, hospital costs, and their need for major surgery (Palmer, 2007). An ISS of 15 or more is regarded as a major traumatic injury with mortality predicted to be at a rate of 10% or higher, however, it has been noted that a total score of 75 is survivable (Palmer, 2007; Karadsheh and Taylor, 2018; Elgin et al. 2019). Elgin et al. (2019) found a total mortality of only 1.58% and 54.95% of their study cohort, that experienced an ISS of 75, were discharged alive. Only a few studies, if any, report on whether the ISS affects the physical function of a patient specifically, and thus should be researched in more detail in order to ascertain whether the ISS can be used as a predictor of physical functional ability in this study population.

No association was found in this cohort between the number of complications developed in the ICU and the level of non-independent physical function at hospital discharge. The lack of association found might be explained by the fact that most of the complications reported were reversible through the provision of adequate and needs-based care. Limited conclusions could be drawn from this finding owing to the amount of missing information in the patients' records.

Most of the research data available regarding physical function and burn injuries pertains to the post-acute stages, subsequent to the hospital stay, and are correlated with QOL, as well as the psychological aspects of the patient. Contractures, for example, have been found to impact upon physical function and to limit physical roles (Leblebici et al. 2006). Moi et al. (2016) reported that 'self-perceived' health is threatened by the development of contractures, and diminished hand function. In saying this, research needs to focus on the acute care and outcomes of patients with major burn injuries.

The number of surgical procedures performed was found to bear no association with the level of non-independent physical function at hospital discharge. In Norway, Moi et al. (2016) reported on a sample population with burns affecting an average of 17.8% (4.4% full thickness) of the total body surface. In this case, 'self-perceived' health found to be threatened by the total number of surgeries that the patient had been subjected to during the hospital stay. As surgeries are performed to improve the patient's health outcomes, it seems plausible that no association was found between the number of surgeries performed and non-independent physical function at hospital discharge. There is currently little evidence available regarding the patient's level of physical function in the hospital after having received a series of surgeries for the management of a major burn injury.

In this study cohort, no association was found between the LOS in the ICU and the hospital with regard to the level of independent physical function at hospital discharge. In the study by Corner et al. (2015), it was specified that on admission, the patient's physical function was at its lowest; this improved once the patient was discharged from the ICU, and further improved at hospital discharge. However, few or possibly no patients returned to their level of pre-morbid physical function when they were discharged from the hospital (Corner et al. 2015). This might suggest that an extended LOS may improve physical function. Research in this area is more focused on whether a specific treatment reduces the length of stay. The association may be lacking as the patients stay in the hospital until they are fit for discharge to a step-down facility or to a rehabilitation centre. Therefore, one can deduct that the length of stay in the ICU and the hospital might be more reliant on how stable the patient is and the treatment they have been receiving and need as opposed to the LOS directly affecting the physical functioning of the patient at discharge. The needs of the patient in terms of care declines over the period of his/her hospital stay (Corner et al. 2015). The patients' functional ability would have reached a certain level before they could be discharged from the hospital. Corner et al. (2015) noted that it would take 27 to 216 days from the time of the burn injury to reach the premorbid function.

5.5 LIMITATIONS OF THE CURRENT STUDY

Few limitations were noted as the study progressed. The lack of data recording was a major reason as to why the results in this study were not significant. It was noted that some of the physiotherapy notes did not commence at ICU admission – this hindered the data collection process and might have affected the results. The practice owner, from whom these data were collected, confirmed that the reason for the fact that the data at ICU admission were missing was due to the instability of the patient on admission (e.g. low platelet level). This might have been due to the severity of the injury which would explain why immediate physiotherapy could not commence (Corner et al. 2015).

Some of the reasons as to why the data pertaining to the condition of the patients subsequent to their admission to ICU might have been missing could be that the therapists assumed that they did not have to record the information if the patient presented as normal (e.g. ROM, muscle strength, muscle length, independent function). Other reasons could be that the practice was very busy, therapist ignorance regarding data keeping, the recording of data proved to be too time consuming or the data sheets might not have had the space to record the information relating to every joint and muscle group. As mentioned in the literature review, poor record keeping, impacts upon the research that can be carried out and therefore on any of the information that could be gleaned from it (Wegner and Rhoda, 2011). As discussed in the literature review, poor record keeping could also hinder the health professional in medico-legal cases, and also obstruct him/her in progressing in their occupation.

The different levels of grading an inhalation injury may affect the results pertaining to mortality and should be included in the statistical analysis for clearer, more definite conclusions regarding the LOS, surgical procedures, the frequency of procedures and complications. As mentioned in the literature review, an inhalation injury can be subdivided into three groups of severity, as well as into three zones, which can be assessed with the aid of a bronchoscope (Hanekom, et al. 2015; Aung, et al., 2018). It is unclear as to whether these different groups and zones would affect the health outcomes of the patient differently. This topic could be researched in future studies.

Another variable that was not considered and recorded in this study but that could have affected the outcomes of the study cohort is the number of times a single complication occurred. A record of the mood of a patient should also be kept in the clinical records as it affects the outcomes of patient care. Psychological distress is a common feature in patients with major burn injuries and continues to impact upon long-term recovery (Fauerbach et al. 2007). A record of the level of pain the patients experience during physiotherapy sessions should also be kept as this too affects patient cooperation, as well as their long-term recovery. Another limitation of this study includes the absence of data regarding the type of burn injury and its association to physical function.

5.6 RECOMMENDATIONS FOR FUTURE

5.6.1 Recommendations for Future Research

To the researcher's knowledge, this is the first study of its kind (globally), and highlights many areas that need to be researched. The identification of factors affecting recovery found in this study may potentially be used in future research to help establish a prognostic guideline for the care of patients with major burn injury. This study is a general overview of the outcomes of patients with major burn injuries and it should be noted that future studies should possibly focus on each objective noted in this study as a separate entity in order to obtain a more comprehensive knowledge of the physical functioning of patients with major burn injuries and what affects their physical functions. Perhaps these discrete studies should be conducted prospectively in order to describe changes in physical function more accurately. This could be done by applying many different physical function outcome measures. Yet another suggested study could focus on the ROM and muscle strength of the study cohort.

The number and type of complications, as well as the surgical procedures, should be recorded for each patient and the physical functional outcomes should be measured for that same patient for more accurate results. Future research could focus on a specific range of complications and surgeries - as long as the patient population would permit it. Further studies could focus on finding associations between the ISS, the LOS, surgical procedures, as well as complications, and physical function, but using a larger sample size. Such studies should be done prospectively in order to capture all of the relevant data needed. Another recommendation would be to create a study that investigates the TBSA involved and the different depths of burn injury as well as the type of injury and how these factors affect physical function. This could also be carried out for the different types of inhalation injury and how they affect not only physical functions, but also the respiratory functions, and the various complications that might arise from an inhalation injury. Should these research recommendations be pursued, more outcome measures could then be used, thus allowing for the collection of more accurate data and more conclusive results.

The distance walked could be measured with outcome measures (e.g. by means of the six-minute walking test) and reported upon more accurately in terms of the different time points in question. As the distance in this study cohort was not measured with a measuring wheel during the mobilisation phase of the patient, only an estimate of the distance walked was provided. This recommendation to use added outcome measures could be extended to independent mobilisation and to stair climbing. A mobilisation study could be combined with other variables and the manner in which those variables affect the mobility of the patients could be determined. The relevant variables could include surgeries, complications, or the injury severity score (ISS), to name but a few.

If another study of this nature were to be conducted, it is recommended that the milestones achieved should be stipulated at more regular intervals and in a lesser time frame, thus allowing more information to be processed so as to obtain a more conclusive data analysis.

Some of the patients in this study remained in the ICU for months and achieved a wide range of physical functions during this period, but these achievements were not recorded adequately as the milestones for this study were specifically ICU admission, ICU discharge and hospital discharge. In saying this, the length of stay in High Care and in the ward was combined in the data received from the Trauma Bank database of the hospital and could possibly be separated to add yet another milestone to the data collection process to ensure a more accurate outcome for patients with major burn injuries.

To combat many of these limitations, it is suggested that this study or a similar one should be conducted prospectively.

5.6.2 Recommendations for Future Clinical Practice

This study was not conducted in a manner that aids in the application of specific treatment techniques or outcome measures in clinical practice. It is an overview of standard procedure in a Burns unit and how that affects patients' physical function at discharge. However, it can be suggested and strongly encouraged that more outcome measures (e.g. measuring wheel or 6-minute walk test for distance walked) be used and documented in future research and clinical practice. Note taking by healthcare workers should be done comprehensively, not only for medico-legal reasons but also to aid future research endeavours and communication amongst the multidisciplinary team.

CHAPTER 6

6. CONCLUSION

Of the 73 patients included in this study, and according to the demographics and clinical characteristics of the study cohorts, the majority were middle-aged males, of black ethnicity and the most common areas burned were the limbs, which were injured mainly through thermal causes. The depth of injury was primarily of a full thickness though partial thickness was recorded as a close second. The severity of injury and the revised Baux score both pointed to a more than 10% risk of mortality. The length of stay in hospital ranged from 7 to 243 days in total, even though the median was 44 days. In this study cohort, there was a large amount of incomplete records thus a small sample size and so the results should be interpreted with caution.

There were 18 different types of surgery noted that some patients underwent repeatedly, with one patient being subjected to a total of 29 surgeries, thus affecting his/her length of stay. Just short of half the patients were intubated and ventilated, while a quarter of the study cohorts were sedated.

This study also looked at the changes in physical function. The wrist and hand presented with decreased ROM throughout this study. This is important to note, as the hand and wrist are essential components contributing to the ADLs. The muscle strength from this study cohort seemed either to be maintained and to remain stable or to be slightly improved. The most common of the two-joint muscles to be shortened as a result of the burns was found to be the Achilles tendon. One should look into the reasons for this and whether, in the case of a shortened Achilles tendon, the ankle sustained burns or not. The other decreased muscular space was the axilla.

Another part of physical function that was focused upon included the issue of independent mobilisation, stair climbing, the Functional Status Score that the patient achieved in the ICU (FSS-ICU). Independent mobilisation steadily improved during the course of the hospital stay. Furthermore, an improvement was also noted in the ability of the patient to climb stairs. The FSS-ICU also improved in conjunction with the above-mentioned factors.

The complications recorded in this study cohort numbered 34, with the maximum number of complications emerging in one patient totalling 21. The most common complication recorded was oedema.

The physical functions presented by the patients at hospital discharge do not seem to be associated with the ISS, the length of stay in ICU and the hospital respectively, the number of theatre visits, and the number of complications that developed respectively. More studies need to be conducted in this regard.

It is important to strive to prevent injuries and to improve on the QOL of those injured through burns. This can be done by applying the results of evidence-based research and by constantly improving the methods of data collection. Researched attempts at preventing further deterioration of burn victims, including treatments and services for those who are disabled (survivors of burn injury) by improving the associated training programmes, through multidisciplinary teamwork and the implementation of such plans, would be worthwhile endeavours (WHO, 2019). There are plans afoot for the development of a centre dedicated to burns that would apply ‘’scientifically-proven measures’’ to reduce the number of burn-related deaths (WHO, 2010; Smolle, et al. 2017). These would include the implementation of lighters, which are child-resistant, the promulgation of smoke alarm laws, laws regarding the recommended temperature of the hot-water tap, educational programmes, and the management of burns victims (WHO, 2010; Smolle, et al. 2017).

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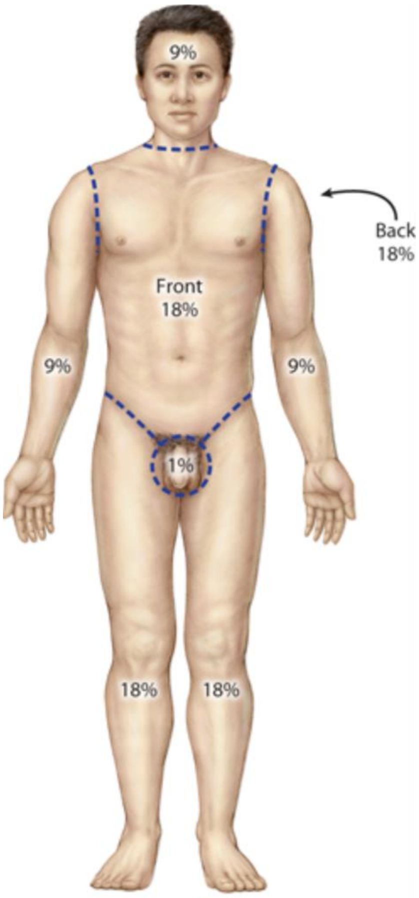
APPENDICES

APPENDIX A

- **RULE OF NINES**



Source: Rose L. Hamm: *Text and Atlas of Wound Diagnosis and Treatment*: www.accessphysiotherapy.com

APPENDIX B

- **REVISED BAUX SCORE**

Revised Baux Score = % TBSA burned + patient age + 17(n)

n = 1 in the presence of an inhalation injury

OR

n = 0 in the absence an inhalation injury

APPENDIX C

- **FSS-ICU**

FUNCTIONAL ABILITIES IN ICU

Functional Status Score for the Intensive Care Unit (FSS-ICU)

(Thursh, Rozek & Dekerlegand (2012), Parry et al (2015), Main & Denehy (2016)

Functional activity	**Score**
Rolling	
Supine to sit	
Sitting on edge of bed	
Sit to stand	
Walking	
Total Score	

<u>Scoring system for rolling to sit to stand:</u>

0 – Unable to perform

1 – Total assistance

2 – Maximum assistance

3 – Moderate assistance

4 – Minimal assistance

5 – Supervision

6 – Moderate independence

7 – Complete independence

<u>Scoring system for walking:</u>

- Is the patient unable to attempt or complete the task of ambulation due to weakness? *If yes, score 0.*
- Can the patient walk less than 50 feet (15 m) with the assistance of one person *or* requires the assistance of two people to physically assist with any ambulation distance? *If yes, score 1.*
- Can the patient walk at least 50 feet (15 m) with the assistance of only one person? *If yes, score 2.*
- Can the patient walk a minimum of 150 feet (45 m) with moderate assistance of only one person (defined as the patient being able to perform between 50 to 74% of the walking effort)? *If yes, score 3.*

- Can the patient walk a minimum of 150 feet (45 m) with minimum assistance of only one person (defined as the patient being able to perform 75% or more of the walking effort)? *If yes, score 4.*
- Does the patient require only supervision or cueing in order to walk 150 feet (45 m) without physical help (the patient may use an assistive device as need)? *If yes, score 5.*
- Can the patient walk 150 feet (45 m) but requires the use of an assistive device such as a cane, walker, crutches, or use of a brace or prosthesis? *If yes, score 6.*
- Can the patient walk 150 feet (45 m) without using an assistive device such as a cane, walker, crutches, or use of a brace or prosthesis? *If yes, score 7.*

APPENDIX D

- **DATA EXTRACTION SHEET**

MAJOR BURN INJURY: PATIENT'S DATA FORM

1. **General Information:**

Date: ___________________

Name of researcher: _______________________________

Report Title: Factors that Influence the Recovery of Physical Function of Adult Patients with Major Burn Injuries

Inclusion criteria: All records of adults with major burn injuries admitted to the Burns Unit over a 36-month period, provided that patients were diagnosed with burns of a total body surface area of 20% or more (excluding superficial burns) with or without inhalation injury.

Exclusion criteria: patients with complex lower limb injuries that would delay physical function (amputation, spinal cord injury, traumatic brain Injury, complex fractures to the pelvis, femur, tibia, fibula); patients with cognitive disorders that would delay physical activity; patients who had died in the hospital.

*Reason for Inclusion:*____

*Reason for Exclusion:*____

DO NOT PROCEED IF PATIENT EXCLUDED FROM STUDY

2. **Data extraction:**

Patient number : _______________________

Age : _______________________

Gender : _______________________

Ethnicity : _______________________

Date admitted : _______________________

Date: ICU Discharge : _______________________

Date: Hospital discharge : _______________________

Total LOS : ______*days*

Length of stay : _______*days in ICU* *Length of stay:* _______*days in hospital*

Severity of injury : _____________________

Revised Baux score (on admission): _____________________

Mechanism of Burn : _______________________

TBSA involved : _______________________

Artificial airway : _______________________

Sedation : ________________________

Number of surgical procedures (name and date, ward): ________________________________
____
____*Total:* _____

Type of complications (name and date, ward): ____________________________________
____
____*Total:* _____

Body parts involved : ____
____
____*Total:*
_____

Joints involved in burn injury: ____
____
____*Total:*
_____

Range of motion (major joints):

Admission ____
____
____
____

Discharge from ICU ____
____
____
____

Discharge from hospital ____
____
____
____

Muscle power

Admission ____
____
____
____

Discharge from ICU ____

____

____

____

Discharge from hospital ____

____

____

____

Muscle length: muscle ____

Admission ____

____

____

____

Discharge from ICU ____

____

____

____

Discharge from hospital ____

____

____

____

Distance walked

Admission ____

____

____

____

Discharge from ICU ____

____

____

____

Discharge from hospital ____

____

____

____

Physical function (FSS-ICU score)

Admission ____

____

____

____

Discharge from ICU ____

____

____

____

Discharge from hospital ____

____

____

____

Splinting: ____

APPENDIX E

- **PARTICIPANT CONSENT FORM**

STUDY INFORMATION AND PARTICIPANT CONSENT

Dear Participant,

My name is Irene Angelou. I am a physiotherapist and registered for a postgraduate degree in Physiotherapy in the Faculty of Health Sciences at the University of the Witwatersrand in Johannesburg. I am requesting your permission to include you in a research study that I am performing towards obtaining my MSc Physiotherapy degree.

Title: Factors that Influence the Recovery of Physical Function of Adult Patients with Major Burn Injuries

The purpose of this research is to provide more information about the recovery of the physical function of adult patients who sustained major burn injuries. South Africa has a high prevalence of patients who experience trauma and burn injury as described by other researchers, and therefore many patients receive physiotherapy intervention during their hospitalisation and after discharge from hospital to assist with the optimisation of their physical function. Research on burn injury in general is very limited, especially with regard to the rehabilitation of the survivors of such injuries. Most of the existing evidence deals with the management of pain and the medical and surgical interventions used for these injuries but little is known about factors that influence the recovery of physical function in patients with burn injury. In order to reduce the incidence of physical dysfunction after major burn injury, it is important to have a firm understanding of specific factors that place patients with such injuries at risk of developing complications, such as deformities and contractures, which negatively influence their recovery of function and quality of life.

<u>Why are you being asked to participate?</u>

You were admitted to Netcare Milpark hospital with a major burn injury during the period January 2015 to December 2017. This research study is a retrospective review of the information captured about your stay at Milpark Hospital on the Medibank/Trauma Bank Database. This information was captured from your medical file while you were an in-patient at Milpark Hospital and we need your permission to extract this information from the database for this study. The only information from your stay at Milpark hospital that we will need for this research study includes the following:

- Age and gender,
- Date of hospital admission and discharge and length of stay,
- Severity of injury and percentage of body surface area burned,

- Number of surgical procedures that you received,
- Type of complications that you developed during your hospital stay, if any.

We also need your permission to extract data from your physiotherapy notes (from Moira Wilson's physiotherapy practice) for this same period of time that you were in hospital for the major burn injuries that you sustained. The only information that we need from the physiotherapy notes is the following:

- Which of your joints were involved in the burn injury?
- Joint range of motion
- Muscle power
- Physical functional ability
- Distances that you were able to walk while in hospital

All of the above information about you will be encoded and will therefore remain anonymous to ensure that your privacy is respected and maintained.

What does the study involve?

This is a retrospective record review and therefore all we need from you is your permission to extract information from the hospital database and the physiotherapy notes for the period January 2015 to December 2017. You do not need to do anything else to participate in this study.

What are the benefits of participating in this study?

There will be no direct benefits to you if you decide to participate in this study. The identification of factors that influence the recovery of the physical function of patients with major burn injury will assist physiotherapists in future to identify patients at greater risk of complications and to construct patient-specific management plans to attempt to minimise complication rates and optimise the recovery of physical function for these patients.

What are the risks associated with participation in this study?

There are no risks associated with your participation in this study.

What is the cost?

There is no cost associated with participation in this study.

Confidentiality and anonymity

If you decide to participate in this study, your information will remain confidential and information obtained from the study will be used for statistical purposes only. I will allocate a study identity code to you which will be used when we enter your information into a password-protected database of information for the study.

What are your rights?

You may withdraw your consent for participating in the study at any stage. No questions will be asked regarding your decision and you will not be penalised for your decision to withdraw.

Should you require any further information, please do not hesitate to contact me, Irene Angelou, on 072 398 9788. If you have any concerns about this study you can lodge these concerns with the chair of the Human Research Ethics (Medical) Committee of the University of the Witwatersrand, Professor Clem Penny at 011 717 1252/2700/1234/2656 or clement.penny@wits.ac.za

Telephonic consent:

I confirm that I have been informed of the nature of the study and its purposes.

I acknowledge that I have heard and understood the information pertaining to the study and that my information will remain confidential throughout the research process.

I acknowledge that I have been given the opportunity to ask any questions about the study that is being conducted and the researcher has answered my questions adequately.

I acknowledge that I may withdraw from the study at any time without bias.

Participant's name : ____

Participant's telephone number: ____

Date of consent obtained : ____

Time of consent obtained : ____

Name of person who obtained consent from the participant:__________________________

Signature : ____

Place : ____

APPENDIX F

LETTER OF PERMISSION

Netcare Milpark Hospital

Tel: +27 (0) 11 480 5600
Fax: +27 (0) 11 482 3317
9 Guild Road, Parktown West, Johannesburg, South Africa
PO Box 91155, Auckland Park, 2006, South Africa
www.netcare.co.za

LETTER CONFIRMING KNOWLEDGE OF NON-TRIAL RESEARCH TO BE CONDUCTED IN THIS NETCARE FACILITY

Dear Irene Angelou

Re Factors that Influence the Recovery of Physical Function of Adult Patients with Major Burn Injuries

We hereby confirm knowledge of the above named research application to be made to the Netcare Research Operational Committee and in principle agree to the research application for Netcare Milpark Hospital, subject to the following:

1. That the data collection may not commence prior to receipt of FINAL APPROVAL from the Sustainability Committee of Netcare (Research Operational Committee).
2. A copy of the research report will be provided to Netcare Research Operational Committee once it is finally approved by the tertiary institution, or once complete.
3. Netcare has the right to implement any Best Practice recommendations from the research.
4. That the Hospital/Site/Division Management reserves the right to withdraw the approval for research at any time during the process, should the research prove to be detrimental to the subjects / Netcare or should the researcher not comply with the conditions of approval.

We wish you success in your research.

Yours faithfully

Sign:..................................

1 9 SEP 2017

Dr Justin Gavanescu
Hospital General Manager

Signed by Hospital Management **Date**

(Specify designation)

Netcare Hospitals (Pty) Ltd T/A Netcare Milpark Hospital
Directors: J du Plessis, R H Friedland, K N Gibson
Company Secretary: L Bagwandeen
Reg. No. 1996/006591/07

APPENDIX G

- **LETTER OF PERMISSION**

Netcare Hospital Management (Pty) Limited

Tel: + 27 (0)11 301 0000
Fax: Corporate +27 (0)11 301 0499
76 Maude Street, Corner West Street, Sandton, South Africa
Private Bag X34, Benmore, 2010, South Africa

RESEARCH OPERATIONS COMMITTEE FINAL APPROVAL OF RESEARCH

Approval number: UNIV-2018-0001

Ms Irene K Angelou

E mail: irene.angelou@yahoo.com

Dear Ms Angelou

RE: FACTORS THAT INFLUENCE THE RECOVERY OF PHYSICAL FUNCTION OF ADULT PATIENTS WITH MAJOR BURN INJURIES

The above-mentioned research was reviewed by the Research Operations Committee's delegated members and it is with pleasure that we inform you that your application to conduct this research at Netcare Milpark Hospital, has been approved, subject to the following:

i) Research may now commence with this FINAL APPROVAL from the Netcare Research Operations Committee.

ii) All information regarding Netcare will be treated as legally privileged and confidential.

iii) Netcare's name will not be mentioned without written consent from the Netcare Research Operations Committee.

iv) All legal requirements regarding patient / participant's rights and confidentiality will be complied with.

v) All data extracted may only be used in an anonymised, aggregated format and for the purposes of this specific study as specified in the proposal. The data may under no circumstances be used for any other purpose whatsoever.

vi) The research will be conducted in compliance with the GUIDELINES FOR GOOD CLINICAL PRACTICE IN HUMAN PARTICIPANTS IN SOUTH AFRICA (2016).

vii) Netcare must be furnished with a STATUS REPORT on the progress of the study at least annually on 30th September irrespective of the date of approval from the Netcare Research Operations Committee as well as a FINAL REPORT with reference to intention to publish and probable journals for publication, on completion of the study.

Executive Directors: R H Friedland, K N Gibson

Company Secretary: L Bagwandeen

Reg. No. 1992/002177/07

viii) A copy of the research report will be provided to the Netcare Research Operations Committee once it is finally approved by the relevant primary party or tertiary institution, or once complete or if discontinued for any reason whatsoever prior to the expected completion date.

ix) Netcare has the right to implement any recommendations from the research.

x) Netcare reserves the right to withdraw the approval for research at any time during the process, should the research prove to be detrimental to the subjects/Netcare or should the researcher not comply with the conditions of approval.

xi) APPROVAL IS VALID FOR A PERIOD OF 36 MONTHS FROM DATE OF THIS LETTER OR COMPLETION OR DISCONTINUATION OF THE TRIAL, WHICHEVER IS THE FIRST.

We wish you success in your research.

Yours faithfully

28/8/18

Prof Dion du Plessis
Full member: Netcare Research Operations Committee & Medical Practitioner evaluating research applications as per Management and Governance Policy

Shannon Nell
Chairperson: Netcare Research Operations Committee
Netcare Hospitals (Pty) Ltd
Date: 29/8/2018

NETCARE

APPENDIX H

- **LETTER OF PERMISSION**

<u>**Letter of permission to Netcare Milpark Hospital**</u>

To Moira Wilson,

My name is Irene Angelou. I am a physiotherapist working at a private hospital and am currently registered for the degree of MSc Physiotherapy at the University of the Witwatersrand. I am requesting permission to perform a research study for my MSc Physiotherapy.

Title: Factors that Influence the Recovery of Physical Function of Adult Patients with Major Burn Injuries.

The purpose of this research is to provide more information with regards to patients with major burn injury. South Africa has a high prevalence of patients who suffer from trauma and burn injury as described in the literature review and therefore many patients receive physiotherapy intervention during their hospitalisation and after discharge from hospital to assist with optimisation of their physical function. Research on burn injury in general is very limited especially with regards to rehabilitation of survivors of such injuries. Most of the existing evidence deals with the management of pain and medical and surgical interventions but little is known about factors that influence the recovery of physical function in patients with burn injury. In order to prevent complications from arising after major burn injury, it is important to have a firm understanding of specific factors that place patients with such injuries at risk of developing complications such as deformities and contractures which negatively influence their recovery of function and quality of life.

The identification of factors that influence the recovery of physical function of patients with major burn injury will assist physiotherapists in identifying patients at greater risk of complications and in constructing patient-specific management plans to attempt to minimise complication rates and optimise recovery of physical function for such patients.

With your permission, the permission of Justin Gavanescu (hospital general manager) and Rene Grobler (trauma research nurse); and with ethical clearance received from the Ethics Committee at Wits University, I would like to conduct a retrospective record review of patients admitted to the Burns ICU of your private hospital. Patients admitted to the burns unit with major burns over the 24-month period, January 2015 – December 2017, are to be identified from the Trauma bank database (according to the predetermined inclusion and exclusion criteria for the study) through the assistance of the trauma research nurse. The trauma research nurse agreed to collate all the relevant information of identified patients into a separate Excel document. This document will not have any identifying patient information and will be provided to myself for data capturing on the designed data extraction sheet for the study. The trauma research nurse agreed to contact you, the physiotherapy practice owner, with the names of identified patients so that you can select the relevant physiotherapy notes for these patients from their records. All identifying patient information should be removed from the physiotherapy notes and the same coding structure followed, as per the Trauma bank database information, to ensure that the same patient's information is collected. I will then collect the coded physiotherapy notes from you and capture the relevant information for this study onto the data extraction sheet. During the data capturing process a second researcher will evaluate a small portion of the data captured to ensure it is captured accurately.

I have applied for ethics clearance to perform this study from the Human Research Ethics Committee of the University of the Witwatersrand and will supply you with a copy of the clearance certificate received, upon receipt.

Should you require any further information please do not hesitate to contact me on 072 398 9788.

Name: MOIRA WILSON Date: 13/2/17 Signature: Moira A Wilson

APPENDIX I

- **UNIVERSITY OF WITWATERSRAND ETHICAL CLEARANCE**

R14/49 Miss Irene Katherine Angelou et al

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M171007

NAME: (Principal Investigator)	Miss Irene Katherine Angelou et al
DEPARTMENT:	Physiotherapy Netcare Milpark Hospital
PROJECT TITLE:	Factors that Influence the Recovery of Physical Function of Adult Patients with Major Burn Injuries
DATE CONSIDERED:	27/10/2017
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Helen van Aswegen
APPROVED BY:	Professor P. Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	30/10/2017

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in October and will therefore be due in the month of October each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

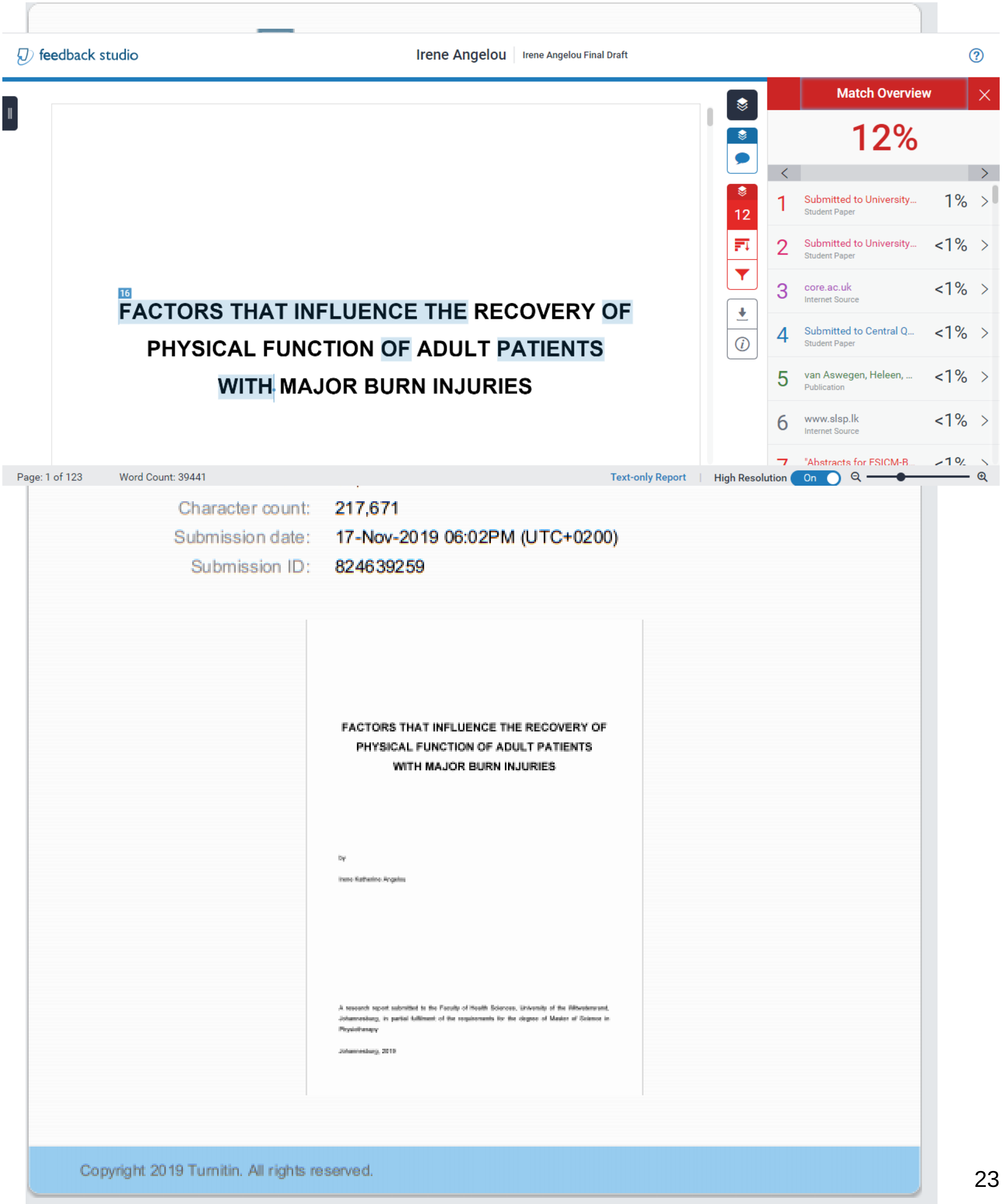
Principal Investigator Signature

Date 31/10/2017

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX J

- **TURN-IT-IN REPORT**



Irene Angelou Final Draft

by Irene Angelou

Submission date: 17-Nov-2019 06:02PM (UTC+0200)
Submission ID: 824639259
File name: 401_Irene_Angelou_Irene_Angelou_Final_Draft_300_336716797.docx (3.09M)
Word count: 39441
Character count: 217671

FACTORS THAT INFLUENCE THE RECOVERY OF PHYSICAL FUNCTION OF ADULT PATIENTS WITH MAJOR BURN INJURIES

by

Irene Katherine Angelou

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Physiotherapy

Johannesburg, 2019

DECLARATION

I, *Irene Katherine Angelou*, declare that this research report is my own work. It is being submitted for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University

______________________________ ______________________________

Signed **Date**

ABSTRACT

Background: Research focusing on patients with major burn injuries is limited, and this applies specifically to the physiotherapy aspects and functional outcomes relating to burns. This study was done so as to review the patients with major burn injuries, their outcomes and the effects of certain aspects of the hospital stay on physical function during the different periods of the hospital stay.

Objectives: The objectives laid out were set to describe the demographic and clinical characteristics of patients with major burn injuries; to describe the changes in physical function of patients with major burn injuries from the respective stages starting with their Intensive Care Unit (ICU) admission until their discharge from hospital; to describe the number as well as the type of complications that patients with major burn injuries develop during their stay in the ICU; to determine whether the severity of injury is associated with physical function at discharge from the hospital; to determine whether there is an association between the complications developed in ICU and physical function at hospital discharge; to determine if the number of surgical procedures performed is associated with physical function at hospital discharge; and to determine if the length of stay is associated with physical function at hospital discharge.

Design: A retrospective record review was conducted to meet the objectives of this research project.

Methods: The study population included adults who had sustained major burn injuries. Information about these patients was sourced from a private hospital in Johannesburg, South Africa, which has a Level 1 Trauma Centre and a Burns Unit. The recorded data in the patients' ICU charts, hospital files and physiotherapy notes were reviewed and only the information needed for this study was extracted. All of the records of patients admitted to the Burns Unit and who were subsequently transferred to a hospital ward were reviewed over a period of 36 months to identify patients that fitted the criteria to be included in this study.

Results: Eighty-four patients were admitted to the hospital in total. Of these 84, 73 fitted the inclusion criteria. Then resulting majority of these patients were male, of black ethnicity, and with a median age of 38. The most common mechanism of injury was of a thermal nature. The median total body surface area (TBSA) burned was 31%, the most common body part to be injured being the upper limbs. The median Injury Severity Score (ISS) was 16 and the mean revised Baux score was 93. Length of stay (LOS) ranged from seven days, with a maximum of 243. The most surgeries a patient underwent amounted to 29. The most common surgery was a debridement. Of the study cohort, 43.8% of the patients were intubated and ventilated and 45.2% needed sedation. Restriction of motion in the hand was noted as the most frequent consequence. The general trend for ROM

seemed to improve over the hospital stay. Muscle strength also seemed to improve during the patients' hospital stay. The muscle length of the Achilles tendon was the most common of the two-joint muscles to have shortened. Distance walked, independent mobilisation, stair climbing and the Functional Status Score (FSS-ICU) seemed to improve throughout the hospital stay. In this study cohort, 12.3% of the patients were discharged to a rehabilitation unit, 8.2% were given an exercise programme on discharge, and 5.5% were given follow-up appointments. The most common complication with 66% of the sampled patients was a low haemoglobin count. No associations were found between ISS, ICU LOS, number of theatre visits, and number of complications developed respectively and non-independent physical function.

Discussion: Den Hollander et al. (2014) stated that the statistics from their study were similar to those of other burns units in South Africa. This statement can be confirmed when the results of this study are compared to those of others conducted in South Africa. According to the demographics and clinical characteristics, the majority of the study cohorts were males, of a black ethnicity, and the areas that were most frequently burned were the limbs. The last-mentioned could be linked to injury on duty as there is evidence that burn injuries generally occur at work e.g. from flammable substances. Furthermore, it was noted that work-related injuries predominantly involve the extremities (Forjuoh, 2006; Hanekom, et al. 2015; WHO, 2019a). Burn injuries [115] can also be sustained at home and during leisure-time activities. It is important to know the percentage of the total body surface area (TBSA) burned and the adverse effects stemming from this event in order for the adverse effects to be prevented as soon as possible.

Taking into account the revised Baux score, it became evident that the majority of the study population (at least 50%) were found to be at risk of mortality, with some potentially needing palliative care. It was found that, as the injury severity score rises, so also does the risk of mortality.

The patient with the longest LOS in hospital was found to be an outlier case with an injury severity score of 29, with a total of 27 visits to the theatre and 17 complications recorded (hallucinations, subluxed joints, contracture, infection, oedema, abdominal cramps, vomiting, diarrhoea, reduced haemoglobin, pyrexia, raised blood pressure, tachypnoea, tachycardia, reduced saturation). An extended LOS allows for rehabilitation in the hospital and healing after the surgeries (e.g. skin grafts) and from the mentioned complications. With regard to the surgeries, it was suggested that the primary cause of surgery was for wound management.

Owing to burn injury and critical illness, the patients might have also presented with increased complications, such as cachexia and muscle weakness (not limited to but also including respiratory muscle weakness), which lead to a lengthened weaning time on the mechanical ventilator, thus necessitating a tracheostomy. Mechanical ventilation (MV) is usually accompanied by sedation.