UNIVERSITY OF THE WESTERN CAPE

Faculty of Community and Health Sciences

Doctoral Thesis

The development of a health care decision-making model to improve survival of persons with traumatic spinal cord injuries (tSCI)

Student name: Blake Boggenpoel

Student number: 2954141

Type of thesis: Doctoral thesis

Department: Physiotherapy

Supervisor: Assoc. Prof Conran Joseph **Co- supervisor:** Prof Anthea Rhoda

Date: 30 November 2022

Keywords: traumatic spinal cord injury, mortality, decision-making model, evidence-based care.

ABSTRACT

BACKGROUND

A scarcity of data exists regarding the processes of care and its effects on mortality and the functioning of patients with traumatic spinal cord injuries (tSCI). To improve survival rates of these patients, one will need to identify processes or personal factors that may cause early mortality and worsen function. Furthermore, these process and personal factors concerning mortality may vary between contexts primarily due to process aspects differing, which should be explored to develop fit-for-purpose decision-making models.

AIM

The overall aim of this study is to contribute to the development of a healthcare decision-making model grounded in existing processes of care and implemented guidelines, which can facilitate the prediction of survival in persons who have sustained a tSCI. In addition, the study set out to achieve the following objectives: 1) determine the profile of participants with tSCI according to the International Core Data Set; 2) evaluate the processes of tSCI care within a specialised acute care setting; 3) conduct a rapid review to establish candidate processes (exposures) of care linked to acute management and survival; 4) determine the prevalence of risk factors for mortality of persons with tSCI according to the theoretical risk model; 5) determine morbidity after tSCI.

METHODS

The overarching study employed a longitudinal, prospective in-hospital study design. It followed participants from the date of injury onset till two years post-injury. Baseline injury characteristics were retrieved from the patient's folder using the SCI core basic data set form. The International Standards for Neurological Classification and Spinal Cord Injury Secondary Conditions Scale assisted in retrieving data related to the American Spinal Injury Association (ASIA) classifications (i.e., motor and sensory scores) and the presence of secondary medical complications during the patient's duration of hospitalisation. Process measures, as included in evidence-based recommendations, were also extracted. Furthermore, the study employed a rapid methodology as outlined by Tricco et al. This methodology was used to identify early predictors of mortality that may be influencing persons who sustained a tSCI. The results from the rapid review were then used to validate injury and process factors as identified in the one-year mortality cases. A case series methodology was used to achieve this, whereby each one-year mortality case was described descriptively.

Data in relation to the above was collected on admission and discharge using a self-developed data extraction form which was based on the following instruments: 1) SCI core basic data set form; 2) International Standards for Neurological Classification; 3) Spinal Cord Injury Secondary Conditions Scale; and 4) key process measures as identified in the literature and clinical guidelines.

The data collection form underwent a two-week piloting period prior to commencing data collection. Data were analysed using descriptive and inferential statistics in SPSS version 28. Moreover, ethical clearance and permission to conduct this study were sought from the University of the Western Cape's (UWC) Biomedical Research Ethics Committee (BMREC) and the Western Cape Department of Health AND Wellness. Permission to conduct the study was also obtained from Groote Schuur Hospital.

RESULTS

In total, 167 participants formed part of this study. According to the demographic profile, those between the ages of 18-30 were most likely to sustain a traumatic spinal cord injury. Assault (65.9%, 110/167), which consisted of gunshot, stabbing and blunt force trauma-related aetiology, accounted for the largest percentage of tSCIs within this cohort. This was closely followed by transport (22.2%, 37/167) and falls (8.4%,14/167) related aetiologies. The mean time to spinal surgery was 11 days and ranged from 0-39 days in length. Following regression analysis, it was found that being male (yes/no) and sustaining an MVA increased the probability of undergoing surgery. Thirty-seven per cent (61/167) of participants were classified as an ASIA A on admission. This was followed by ASIA D (18%,30/167), C (11.4%,19/167) and B (7.2%,12/167). The mean length of hospital stay for participants is 42.6 days and ranges from 0-267 days. Factors found to have influenced the length of hospital stay included spinal surgery status (yes/no), AISA A classification on admission (yes/no) and Tetraplegia (yes/no).

Results of the rapid review found factors related to early mortality to be predominantly orientated toward baseline injury characteristics on admission and other clinical markers. These predictors were broadly grouped based on demographical, injury and process-related factors. In addition, all the studies included in the rapid review came from developed countries.

In total, seventeen participants died within the first two years post-injury – eleven within the first year post-injury and an additional six within the second-year post-injury. From this case series, it was found that reasons which influenced mortality in the one-year mortality cases consisted of a combination of personal/injury factors (i.e., age gender, associated injuries, vertebral injuries, ASIA level) as well as process factors (i.e., intermittent hospitalisation, delayed time to spinal surgery, the occurrence of secondary medical complications during length of hospital stay, unsuccessful procedure [i.e., cervical reductions]). All personal/injury and process factors mentioned above were found to have high positive predictive values, which is clinically important for screening purposes.

CONCLUSION

Early predictors of mortality affecting persons with tSCI are multifactorial and should be addressed to improve patient longevity. Furthermore, personal/injury and process factors which were found to have influenced early mortality have contributed to the development of a preliminary healthcare decision-making model that may help predict survival in persons who have sustained a tSCI. There is an immediate need to assess the predictive validity of the emergent model to facilitate improved survival.

DECLARATION

I declare that ***"The development of a health care decision-making model to improve survival of persons with traumatic spinal cord injuries (tSCI)"*** is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Name: Blake Boggenpoel   Date: 30/11/2022

Signed:

DEDICATION

Thank you, mom for all the sacrifices you have made to get me to where I am today, and all the prayers that assisted me in reaching this goal. I will never forget what you taught, and did for me when growing up. I might not be able to repay you but this one is for you.

To my wife Zsa-Zsa. Thank you for always providing a listening ear and supporting me when I was going through a slump, and providing advice even if it meant that I was on the receiving end. Thank you for being a pillar of support through all these years.

To Zac and Matthew, thank you for always providing a much-needed distraction from my work and studies, without you two life would not be entertaining.

ACKNOWLEDGEMENTS

- First, I would like to thank the Lord for all his blessings and for helping me through this journey. Without him, I would not be where I am today and achieved what I have achieved.

- To my supervisors Prof Conran Joseph and Prof Anthea Rhoda, thank you for all your guidance throughout this journey. I have learnt a great deal from both of you.

- I would also like to say thank you to all the staff within the department that accommodated my absence to complete my PhD when I received teaching relief.

- The work reported herein was made possible through funding by the South African Medical Research Council through its Division of Research Capacity Development under the Bongani Mayosi National Health Scholars Programme from funding received from the Public Health Enhancement Fund / South African National Department of Health. The content hereof is the sole responsibility of the researcher and does not necessarily represent the official views of the SAMRC.

- Thank you to the ASCI unit at Groote Schuur Hospital for allowing me to conduct my research within the unit.

- Thank you to the all the participants of this research study. Without you, this study would not have been possible.

- Thank you to the Office of the DVC Research and Innovation (R and I) for funding that I was afforded to be me in 2022 to complete my PhD.

- Lastly, to my mother-in-law Jean, thank you for always enquiring how things are going with my studies and offering a word of support

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER ONE

BACKGROUND TO THE STUDY

1.1 INTRODUCTION

Making the right clinical management decision at the right time is important when working towards improving the chances of survival and optimal prognosis following an acute injury such as a traumatic spinal cord injury (tSCI) (Choi & Forrester, 2022). tSCI are seen as debilitating injuries which usually occur unexpectedly, depriving individuals of their physical, social and vocational well-being (Ahuja et al., 2017), predominantly during the prime of their lives. Spinal cord injuries (SCI) can be divided into two main groups: traumatic and non-traumatic. These types of SCIS can further be characterised into two categories: complete and incomplete injuries, which could be objectively assessed using the International Standards of Assessment of Neurological Classification, i.e., the American Spinal Injury Association (ASIA) impairment scale (Kirshblum et al., 2011). Besides the loss of function, these patients are prone to developing secondary conditions such as pressure ulcers, urinary tract infections and autonomic dysreflexia, to name a few, which affect their overall prognosis and long-term survival (Joseph & Wikmar, 2016; Madasa et al., 2020; Stillman et al., 2017).

When comparing the survival rates of tSCI to non-traumatic spinal cord injury (nTSCI), it is clear that patients with a nTSCI have a poorer chance of survival than those who have sustained a tSCI (Van Den Berg et al., 2010). Although this is the case, the current life expectancy of persons who have sustained a tSCI is still well below that of the general population in developed countries such as England and Wales (Savic et al., 2017). To date, there has been a noticeable increase in survival due to improved healthcare services and a more focused care package which is patient centred and specifically geared towards persons with tSCIs (Savic et al., 2017). However, studies from more developing countries show trends of a higher percentage of in-hospital mortality (Kang et al., 2017). Thus, specialised and comprehensive acute care in-hospital is essential to optimise the recovery and long-term survival of persons with tSCI.

In-hospital mortality, numbers ranged from 7% in developed countries to 20.5% in developing countries (Chamberlain et al., 2015). A recent study conducted in South Africa on persons four years post-tSCI found the mortality rate to be approximately 24% (Madasa et al., 2020), which is a relatively high percentage compared to more developed countries whose figures are much lower. However, the findings of this study are most likely an underestimation of the actual mortality rate due to the study's high loss to follow-up of participants. A large population-based cross-sectional study conducted in 22 European countries found a pooled age-standardised mortality ratio of 6.7 per million for persons who had sustained a tSCI (Majdan et al., 2017). However, the study by Majdan et al. (2017) is not comparable to that of Chamberlain et al. (2015), as the data was not based on the total number of hospital admission of persons following a tSCI. Furthermore, a review by Chiu et al. (2010) found mortality rates that ranged from 3.1 to 17.5 per million people in developing countries, such as Russia, Bangladesh, Thailand, Taiwan, China, and Nigeria, compared to a mortality rate of only 8 per million in a developed country such as Canada. Based on the findings by Chiu et al. (2010) no conclusive statements can be made in relation to the differences in mortality rates between developed and developing countries. There is therefore a need to investigate the acute management of persons with tSCI and the extent to which demographic, injury, and process-related factors contribute to survival or not.

More specifically, before adjusting the acute care pathway for these patients, we need to identify the process of care (as outlined in Chapter 2 Table 2.2), injury and demographic-related factors related to mortality and adverse outcomes. The higher rate of mortality in developing countries compared to developed countries could be attributed to the lack of adequate resources (Ahuja et al., 2020; Khosravi et al., 2022; Maphumulo & Bhengu, 2019), infrastructure and specialised care services (Gupta, 2019; Gupta et al., 2011; Madasa et al., 2020) in specifically managing patients with tSCI post-injury. Specialised SCI care serves to improve patient outcomes relating to care practices and neurological recovery, while non-specialised care provides a more generalised approach to the management of these patients, which is not necessarily SCI focused. Studies which were conducted within the South African context have proven that a relatively large proportion of persons who sustain tSCI's develop at least one secondary medical complication during acute care (Joseph & Wikmar, 2016), with the prevalence of secondary medical complications still being relatively high four years post-injury (Madasa et al., 2020). The high prevalence of secondary medical complications following discharge likely further increases the readmission rates of patients to healthcare facilities (Mashola et al., 2019), which in turn increases the load placed on an already struggling healthcare system.

As noted above, the physical and psychological effects following a tSCI are usually long term (Ahuja et al., 2020) and are better managed using a specialised care package to improve patient outcomes. In most instances, a non-specialised approach could be responsible for reduced long-term survival and the prevalence of secondary complications among patients who have sustained a SCI. Currently, there has been an upsurge in the number of best practice guidelines to facilitate the management of persons who have sustained a tSCI. The first of such guidelines for acute spinal injury management were those developed by the American Association of Neurological Surgeons (AANS) in 2002, with an update performed in 2013 (Walters et al., 2013). After this, a set of clinical guidelines from the National Institute for Health and Care Excellence (NICE) in 2017 further highlighted key recommendations that should be considered when managing this group of patients. Since this, many research entities/units, such as the Fehling laboratory, have worked on updating clinical evidence to improve care processes relating to tSCI. These clinical guidelines mentioned above strive to be holistic and include recommendations for both acute- and post-discharge phases. However, clinical guidelines are not consistently implemented in certain contexts due to:

- personal factors (related to physicians' knowledge and attitude);
- external factors (related to philosophy, management and leadership within the clinical setting); and guideline-specific related factors (concerning a lack of evidence, access to the guideline, lack of applicability and plausibility of recommendations, to name but a few) (Fischer et al., 2016).

The set of clinical guidelines which specialised SCI care adheres to advocate for the following process measures: i.e., spinal surgery to be performed more routinely and within <24 hours; access to multidisciplinary care, which includes specialist neurosurgeons, rehabilitation specialists, psychologists, social workers and dieticians; assessment of associated injuries should be performing a detailed and complete trauma survey; presence of secondary complications should be minimised especially in relation to cardiovascular and respiratory complications; length of acute care can be reduced by improving transfer logistics post-injury and access to rehabilitation when it is safe to commence (Consortium for Spinal Cord, 2008; Fehlings et al., 2011; Fehlings, Tetreault, Aarabi, et al., 2017; Fehlings, Tetreault, Wilson, Kwon, et al., 2017). In addition to the above, demographical factors such as advancing age (Furlan, Bracken, et al., 2010) and gender (Shibahashi et al., 2019; Varma et al., 2010) have been proven to influence the early mortality of persons who sustained a tSCI.

Currently, insufficient evidence exists regarding the aforementioned process measures of care (i.e., how patients are clinically managed from the onset of injury till discharge from care) followed in the South African context when managing persons with tSCI. This lack of evidence relating to process measures thus creates a challenge in aligning the current health services to a specialised care approach, or current clinical guidelines. An example of quality improvement with respect to tSCI management would be the use of acute care guidelines in specialised care. Specialised care, which consists of timely access to surgery, level one trauma units, rehabilitation and a multidisciplinary team has been shown to decrease mortality, prevent the occurrence of secondary conditions and reduce the length of hospital stays (Consortium for Spinal Cord, 2008; Parent et al., 2011). Countries such as Norway, Netherlands, Italy, Portugal and the United States of America are a few of the countries in the process of using a specialised means of care for patients who have sustained a tSCI (Baricich et al., 2017; Campos et al., 2017; Post et al., 2017a; Richards et al., 2017; Strom et al., 2017). To further improve the quality of care being delivered, these countries set up dedicated spinal units with trained personnel to manage patients who have sustained SCIs better. In addition, these care centres allow for timely access to level one trauma centres, with patients undergoing spinal surgery within 24hours following their injury. Rehabilitation services in these specialised spinal units are also integrated into the early acute phase in order to improve functional outcomes. Currently, research has proven that treatment at specialised centres or SCI care units has improved patient outcomes related to the length of hospital stay, occurrence of secondary medical complications and rate of mortality (Parent et al., 2011). Furthermore, countries such as Italy and Portugal have incorporated legislation which governs how persons with disability should be managed in a holistic and multidisciplinary way (Baricich et al., 2017; Campos et al., 2017; Richards et al., 2017). In addition, access to vocational or dedicated SCI rehabilitation centres to improve community reintegration has been made available. However, ensuring that this is an option for all patients could be affected by the system being employed by the national health body and private insurance companies (Baricich et al., 2017; Campos et al., 2017; Post et al., 2017b; Richards et al., 2017; Strom et al., 2017). Many patients may be unable to cover the costs of care; hence, supplementary cover may be needed by patients to cover certain medical visits (Post et al., 2017b). Although the various measures mentioned above have been implemented to improve patient outcomes related to persons who sustained SCI, premature death remains a reality in this vulnerable group. Hence, mechanisms which can predict mortality and improve survival would be advantageous in systematically strengthening healthcare systems for persons with tSCI, with the aim, initially, to promote survival and subsequently facilitate recovery and functioning.

Due to high complication rates and premature mortality in South Africa, one could suggest that a non-specialised care approach is being utilised (Conradsson et al., 2018). To date, only a limited number of South Africa facilities can offer specialised services for persons with tSCI. South African patients who sustain a tSCI and require further intervention are likely to only undergo surgery within 3-11 days from the onset of injury (Miseer et al., 2019), which is not in line with best practice guidelines which states that surgical intervention should be provided within the first 24hours to limit neurological degradation (Fehlings, Tetreault, Wilson, Aarabi, et al., 2017). Furthermore, not all patients are eligible for admission to specialised SCI rehabilitation centres post-discharge as they are required to undergo strict admission criteria, which in turn impacts those patients that do not meet the eligibility criteria as set out by the facility (Joseph, Scriba, et al., 2017). In addition, certain services such as peer support, which assists patients in coming to terms with their "new self" is slowly being phased out due to financial constraints within the sector (Joseph, Scriba, et al., 2017), even though there is anecdotal evidence suggesting its effectiveness in inpatient and community settings (Barclay & Hilton, 2019).

Hence, as we work towards an evidence-based approach in patient management, identifying factors that may negatively impact survival could assist in improving the health system and quality of life of these patients. Having a decision-making model in place could assist in redirecting these services and other valuable resources to patients who are at a high risk of early mortality, thus improving survival. Decision-making processes within the healthcare context are complex but integral to improving patient management by ensuring a more structured approach to decisional processes employed by clinicians at the point of care(Sutton et al., 2020). Novice clinicians often struggle with decision-making processes due to their lack of experience, while seasoned and more experienced clinicians often base their knowledge on prior clinical situations and not on the best available evidence (Smith, 2008). Neither of these scenarios are desirable as it may lead to negative patient outcomes since the latest advancement and practice guidelines may not be implemented. Furthermore, decision-making tools are vital in the quality improvement process, as they can be used to support a deviation in care practices where credible evidence is unavailable to inform change (Bae, 2014). Although a decision-making tool has been developed to determine survival in persons with tSCI (Fallah et al., 2022), it was published in a developed country and may therefore exclude candidate exposures which are otherwise more prevalent in a developing country such as South Africa. Hence, more research is needed to identify context-specific candidate exposure impacting survival in low- to middle-income countries, which will contribute to developing context-specific decision aids. In addition, the use of clinical decision-making tools for quality improvement is of benefit if we wish to improve the care continuum for persons who have sustained a tSCI. However, to develop such a tool, it is important to first identify context-specific factors that influence the care continuum and survival of these patients.

A theoretical risk model developed in the United States of America (USA) by Professor James Krause was designed to predict mortality in persons with SCI (Krause, 1996).
The model has identified four domains which include:

- modifiable (i.e., psychological factors, socio-environmental factors, risk behaviour factors; secondary conditions/global health factors);and
- non-modifiable (i.e., demographic and injury factors) variables that were found to be predictive of early mortality.

Krause's theoretical risk model consists of the following domains, which are important when determining the risk of mortality in persons who have sustained SCI (1) demographic/Injury factors, (2) psychological/socio-environmental,(3) protective/risk behaviour, (4) health and secondary conditions (Krause, Carter, et al., 2009).

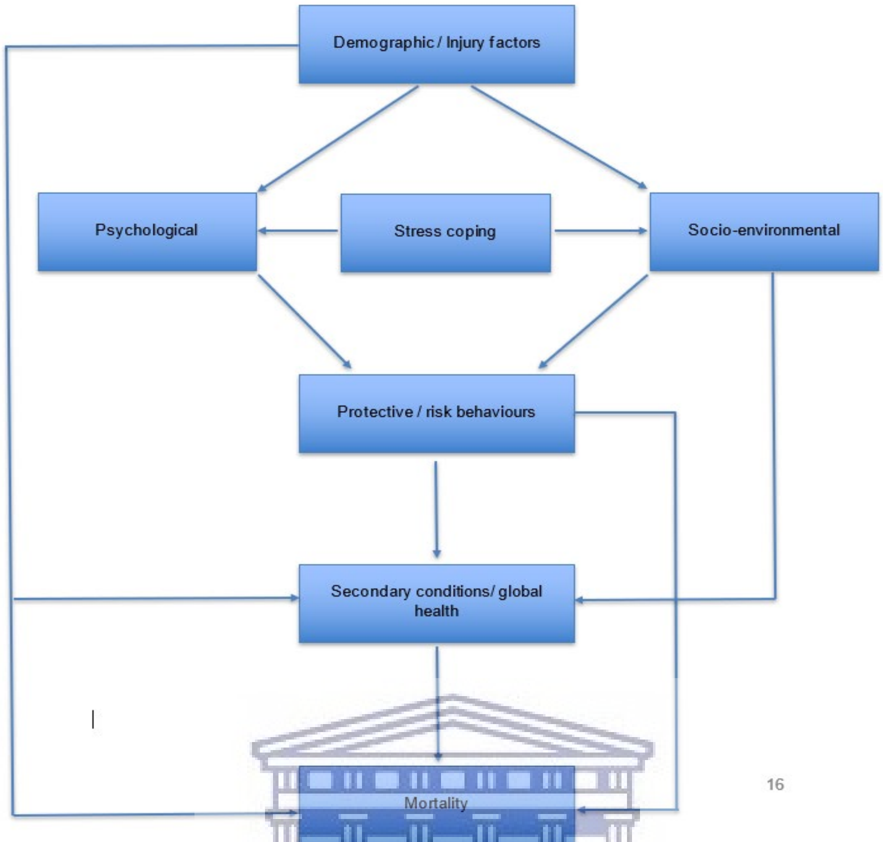


Figure 1.1 Krause's theoretical risk model (Krause, Zhai, et al., 2009)

Using Krause's theoretical risk model, the researcher can identify predictive factors of cause-specific mortality which could enable tailored intervention/prevention programmes to decrease the exposure of risk to mortality, thus improving patient survival (Cao, DiPiro, Krause 2019). This moves away from the concept of only focusing on all-cause mortality, which is defined simply as all deaths that may occur within a given population regardless of the cause of death. Furthermore, the model can be used to determine system factors related to mortality, such as the quality of the prevention programmes being used = (Protective/Risk behaviours); occurrence of secondary complications = (Secondary conditions/Global health) and the presence of a specialised care environment i.e., time to surgery (socio-environmental). Lastly, it is integral to the development of a healthcare decision-making model, as it will assist in identifying the candidate factors related to mortality and survival. One limitation or critique of such conceptual models is the lack of clarity on what variables should be included in each domain, and how it should be measured. On the other hand, recognising the role of context and local healthcare environments, key factors related to mortality should emerge from features relevant to the setting. Hence, Krause's model is considered as a conceptual model instead of a theoretical model, which would assume that empirical research confirmed the relationship and proximity of exposures on outcomes.

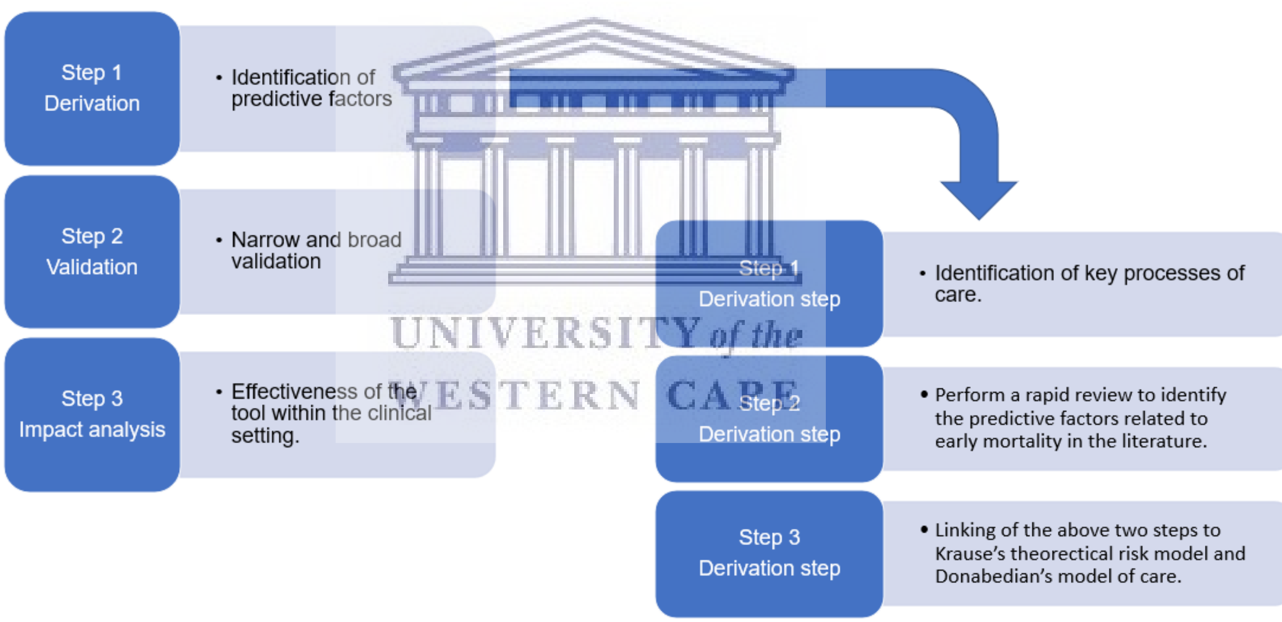


Figure 1.2 Development process of a prediction tool to inform decision making.

As seen in Figure 1.2 above, this study seeks to only contribute to the development of a decision-making model by identifying exposures that are linked to early mortality. The validation and impact analysis steps can only be done once a list of possible predictive factors have been identified. To identify candidate exposures of mortality and survival, one would first need to identify the key processes of care related to the management of persons who have sustained a tSCI. Second, one would need to consult the literature regarding the predictive factors linked to survival and mortality by specifically distinguishing process from demographic and injury-related factors. To assist with unravelling the relevant contextual factors, a rapid review methodology is advisable, as the findings generated will expedite the knowledge-to-practice gap by informing policy briefs in the management of these patients. Third, one would then need to link the processes of care and candidate exposures identified in the literature to that of Krause's theoretical risk model, which has been suggested to predict mortality in persons with SCI. Ultimately, each step provides input with respect to developing a crude model, but more importantly, a concrete and immediate starting point for the prediction of survival, while at the same time employing a systems approach to patient management.

1.2 PROBLEM STATEMENT

tSCIs cause considerable consequences and cost society millions of rands. South Africa is reengineering its primary health care services to improve quality of care while maintaining high levels of access and affordability (Joseph, Scriba, et al., 2017). However, the process of restructuring the healthcare system still remains a work in progress (Maphumulo & Bhengu, 2019). According to the researcher, no specialised and comprehensive pathway of care is available for all persons with tSCI, and no information on mortality and other pertinent outcomes is available (Joseph, Scriba, et al., 2017), which is necessary if we wish to develop SCI focused care packages specifically geared to improve the health and well-being of these patients while addressing historical injustices such as unequal access, unaffordability, and healthcare inequality. To achieve this, one would need to include a rigorous observation of key processes/interventions central to the management of SCI and how these interventions impact survival in the medium and long term. Medium and long-term in relation to this study will be defined as 3 to 6 months and 6 months to 1-year post-injury, respectively. The literature is not clear as to what is defined as medium and long-term survival in the context of SCI, however based on the study by Mccoll et al. (1997), short- and medium-term survival ranged from 7 to15 years post-SCI (Mccoll et al., 1997), while long-term survival was considered to be 20 years and onwards (Frankel et al., 1998; Mccoll et al., 1997). However, this is dependent on context and the quality of health services.

Current knowledge regarding the acute management of SCI is that early intervention is key to improving patient outcomes. These time-sensitive interventions include surgery, rehabilitation, diagnostic imaging, and access to level one trauma facilities which have specialised spinal units (Fehlings et al., 2011; Fehlings, Martin, et al., 2017; Fehlings, Tetreault, Aarabi, et al., 2017; Fehlings, Tetreault, Wilson, Aarabi, et al., 2017; Walters et al., 2013), have been shown to decrease the chances of early mortality thus improving life expectancy. However, it is hard to determine the cut-off points for interventions where the benefits still outweigh the harms. Furthermore, obtaining data with respect to the processes of care and mortality are necessary if we wish to motivate the redistribution of resources to strengthen the quality of care which is to provide quality care to all in need. If quality care (right care) is provided at the right place and right time the chances of long-term survival increase due to the decreased impact of injury-related factors on survival outcomes (Mccoll et al., 1997).

Patient care is not necessarily made using the best available evidence due to the lack of a decision-making model. A decision-making model that assists in determining survival in low and middle-income countries (LMIC) such as South Africa allows one to successfully stratify patients into high or low-risk groupings which is necessary especially within the South Africa context which is a resource constrained environment. This would inevitably improve patient outcomes, particularly with respect to survival, and assist in the redistribution of care services. In addition, the presence of a decision-making tool will assist in improving care processes by providing a structured approach to patient management, especially in instances where evidence is lacking. Furthermore, patients who are classified as being high risk might not receive the necessary care, they require to improve their chances of survival, as medical practitioners may find it challenging how best to manage these patients due to a lack of expertise and training if no system is in place to guide their decisional processes. Hence, this study aims to lay the foundation with respect to the development of a preliminary decision-making tool for the prediction of mortality following acute tSCI.

1.3 RESEARCH QUESTION

What are the variables and their utility in informing the development of a health care decision-making model for predicting survival in persons with tSCI?

1.4 AIM OF THE STUDY

The overall aim of this study is to contribute to the development of a healthcare decision-making model grounded in existing processes of care and implemented guidelines, which can facilitate the prediction of survival in persons who have sustained a tSCI.

1.5 OBJECTIVES OF THE STUDY

1.5.1 Determine the profile of participants with tSCI according to the International Core Data Set

- To determine the characteristics (i.e., age, sex, aetiology, associated injuries, vertebral injuries, spinal surgery, length of hospital stay) of all tSCI participants who have sustained a tSCI enrolled in the cohort for an 18-month timeframe.
- To determine the mortality rate of the tSCI cohort during acute care and one year after injury onset.
- To descriptively study the one-year and two-year mortality cases based on their key exposures in terms of successes and failures.

1.5.2 To evaluate the processes of tSCI care within a specialised acute care setting

- To determine the timing of time-sensitive interventions related to the time to surgery; time to specialised care, which includes time to acute care from intermediate hospitalisations and time to rehabilitation.
- To determine the total length of hospital stays.

1.5.3 To conduct a rapid review to establish candidate processes (exposures) of care linked to acute management and survival

- To identify independent predictors of early mortality of persons who sustained a tSCI.

1.5.4 To determine the prevalence of risk factors for mortality of persons with tSCI according to the theoretical risk model

- To determine the injury factors (i.e., severity and associated injuries).
- To determine the risk indicators (i.e., comorbidities and secondary medical complications).

1.5.5 To determine morbidity after tSCI

- To determine neurological recovery from admission to discharge.
- To determine functional recovery from admission to discharge.

1.6 DEFINITION OF TERMS

- Acute injuries: *"Acute injuries are of sudden onset, caused by high intensity forces, and of short duration"* (Knight, 2008).

- Abnormal imaging: Any form of diagnostic imaging that has identified damage to the spinal column /spinal cord that may results in neurological fallout.

- Traumatic spinal cord injury (tSCI): A traumatic spinal cord injury is an injury to the spinal cord which is brought about by a traumatic event such as a motor vehicle accident, fall etc. (Ahuja et al., 2017).

- Non-traumatic spinal cord injury (nTSCI): A non-traumatic spinal cord injury is caused by various medical conditions (Ahuja et al., 2017).

- Complete spinal cord lesion: A complete spinal lesion is defined as complete loss of motor and sensory function below the injury level (Ho et al., 2007).

- Incomplete spinal cord lesion: An incomplete spinal lesion is defined as partial loss of motor and sensory function below the injury level (Ho et al., 2007).

- Tetraplegia: The loss of motor and/or sensory function in the cervical segments. In most instances, all four extremities will be affected (Nas et al., 2015).

- Paraplegia: is defined as the loss of motor and /or sensory function in the thoracic, lumbar, or sacral segments. In most instances, the trunk, pelvis and lower extremities are usually affected (Nas et al., 2015).

- Secondary medical condition: A "*condition that is causally related to a disabling condition (that is, occurs as a result of a primary disabling condition) and that may either be a pathology, an impairment, a functional limitation or an additional disability*" (Jensen et al., 2013).

- Mortality: The number of individuals who are at risk of dying within a specified time period. (Porta et al., 2008).

- Epidemiology: The *“study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control health problems”* (Porta et al., 2008).

- Sensitivity: The “*ability to identify those individuals who do not have the disease in question”* (Swift et al., 2020).

- Specificity: The *“ability to identify those individuals who have the disease in question”* (Swift et al., 2020).

- Negative predictive value: If an individual has a negative test, what is the probability that the individual does not have the disease in question (Monaghan et al., 2021).

- Positive predictive value: If an individual has a positive test, what is the probability that the individual has the disease in question (Monaghan et al., 2021).

- Prevalence “*represents existing cases of a disease and can be seen as a measure of disease status; it is the proportion of people in a population having a disease”* (Noordzij et al., 2010).

1.7 EXPLANATION OF ABBREVIATIONS

- AANS: American Association of Neurological Surgeons
- ACDF: Anterior cervical decompression fusion
- AIS: Age and neurological injury severity
- ASIA/AIS: American Spinal Injury Association or ASIA Impairment Scale
- ATLS: Advanced trauma life support
- AUC: Area under the curve
- BMI: Body mass index
- CCI: Charlson comorbidity index
- CCS: Central cord syndrome
- CPR: Clinical prediction rules
- EMS: Emergency medical services
- GDP: Gross domestic product
- GRADE: Graded Recommendation Assessment Development and Evaluation
- GSH: Groote Schuur Hospital
- ICU: Intensive care unit
- ID: Identity Document
- ISS: Injury severity scale
- LMIC: Low and middle-income countries
- LOS: Length of hospital stay
- MCAR: Missing Completely at Random

- MLA: Machine learning algorithm
- MVA: Motor vehicle accidents
- NHI: National Health Insurance
- NICE: National Institute for Health and Care Excellence
- NPS: Neuropathic Pain Scale
- NPV: Negative predictive values
- nTSCI: Non-traumatic spinal cord injury
- POPI: Protection of Personal Information
- POPIA: Protection of Personal Information Act
- PPV: Positive predictive values
- PVA: Pedestrian-vehicle accidents
- SAMRC: South African Medical Research Council
- SCI: Spinal cord injuries
- SCI-SCS: Spinal Cord Injury Secondary Health Conditions Scale
- SMR: Standardised Mortality Ratio
- TBI: Traumatic brain injury
- tSCI: Traumatic spinal cord injury
- UTI: Urinary tract infection
- UWC: University of the Western Cape
- VAP: Ventilator-Acquired Pneumonia
- WCRC: Western Cape Rehabilitation Centre
- WHO: World Health Organization
- WHO: World Health Organization

1.8 OUTLINE OF THESIS CHAPTERS

Chapter 1: Introduction

Chapter one provides the background and theoretical framework with respect to this specific study and outlines the specific aims and objectives. Furthermore, this chapter gives an overview with respect to the studies rationale and problem statement.

Chapter 2: Literature review

Chapter two provides an extensive yet concise review of key literature relating to the incidence, prevalence, aetiology and mortality related to persons who have sustained tSCI. Risk stratification and the use of decision-making tools are also highlighted. Furthermore, the chapter highlights the differences in measures of disease frequency by comparing rates between developed and developing countries which brings to the fore South Africa's position relative to more developed countries. In addition to the above, Krause's theoretical risk model was discussed, which formed the guiding framework of this study in determining predictors of early mortality.

Chapter 3: Rapid review

Chapter three describes the methodological steps and findings of the rapid review that was conducted to identify the predictors of early mortality in persons who have sustained tSCIs. All literature pertaining to early mortality was reviewed and appraised to assess methodological rigour. In addition, the final list of articles that met the eligibility criteria are provided in a table format highlighting each study's key predictors with respect to early mortality.

Chapter 4: Methodology

Chapter four provides the methodological steps that were followed in order to reach the objectives as set out in Chapter 1. In addition, a description of the study design, research setting, population and sampling technique, data collection procedure and data analysis were outlined. Furthermore, the ethical considerations related to the process of conducting this study was explained.

Chapter 5: Results

Chapter five provides a descriptive quantitative analysis of the cohort that was recruited to participate in this study. This descriptive analysis related to the baseline characteristics of the incidence cohort, which included data relating to the aetiology, spinal injuries and concomitant injuries, length of hospital stays (within each area of care), secondary medical complications and functional data (specifically relating to ASIA classification). Furthermore, this chapter reported on the various associations found between variables.

Chapter 6: Survival model

Chapter six descriptively reports on the first- and second-year mortality cases based on their key exposures (i.e., age, gender, aetiology, intermittent hospitalisation, vertebral injury, secondary complications, associated injuries, time to surgery, ASIA classification on admission) in terms of successes and failures (i.e., whether exposures were present and whether they were aligned to the best available evidence). In addition to this, a sensitivity analysis of all candidate exposures was performed to determine their predictability of vital status at one year. Furthermore, these candidate exposures were grouped under specific domains using Donabedian's model of care and Krause's theoretical risk model, thus providing areas for systems strengthening.

Chapter 7: Discussion

Chapter 7 discusses the study's main results from Chapter 5 (i.e., Results) and Chapter 6 (i.e., Survival model) in detail, and compares it to current literature.

Chapter 8: Conclusions, recommendations and limitations

This chapter discusses the concluding points, recommendations, and limitations concerning developing a decision-making tool to improve the survival of persons who have sustained a tSCI.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discusses key literature on the incidence, prevalence, aetiology and factors impacting mortality with respect to persons who have sustained a traumatic spinal cord injury (tSCI). Furthermore, it describes the current management of spinal cord injuries (SCI) within the South African context. In addition, it expands on the concepts of risk stratification and clinical decision making, which are essential in providing quality care and improving patient outcomes. Models of risk stratification and care, specifically Krause's theoretical risk model, which is the guiding framework in this thesis, and Donabedian's model of care, will be discussed in relation to how they can be used to operationalise and predict early mortality.

2.2 EPIDEMIOLOGY AND TRAUMATIC SPINAL CORD INJURIES

Although there have been many definitions over the past several decades relating to epidemiology, these definitions have gradually changed to be more representative of what the field of epidemiology entails. A definition that sums it up quite well is that of Porta et al. (2008, pp. 81), which states that epidemiology can be defined as "*the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control health problems*". The World Health Organization (WHO), on the other hand, defines the concept of health "*as the state of complete physical, mental and social well-being and not merely the absence of disease* *or infirmity*" (World Health Organization, 1946, pp. 1). Taking into account these two definitions, one can state that epidemiological studies, which seek to determine the relationship between exposure and outcome, can be used to answer a wide range of clinical questions, including those that gravitate towards physical, mental and social well-being. If epidemiological measures are used to measure injury frequency (i.e., incidence, prevalence, aetiology, and mortality rate), a more tailored approach to preventative measures can be established. This can curb the occurrence of injuries and improve the survival rate of persons with SCI. This will, in turn, improve current care processes and preventative programmes in the management of these patients. Determining the mortality rate and identifying factors affecting survival will also allow us to expand on existing epidemiological studies which affect survival will also allow us to expand on existing epidemiological studies conducted in this area (Joseph et al., 2015; Sothmann et al., 2015). The sections that follow will include evidence pertaining to the incidence, prevalence, aetiology and factors which may contribute to the mortality of persons who have sustained tSCI's.

2.2.1 Incidence of traumatic spinal cord injury

The incidence of traumatic spinal cord injuries in sub-Saharan Africa was estimated to be at 29 per million people, according to a 2011 global update (Lee et al., 2014). More than a decade ago, a study by Velmahos et al. (1995) estimated the incidence of tSCI in South Africa to be approximately 48.5 cases per million; however, this was a single centre cohort in Johannesburg from 1988 – 1992. While a study conducted in South Africa by Joseph et al. (2015), found the incidence rate of tSCI within the Cape Metropolitan region alone to be 75.6 cases per million, which is alarmingly high when compared to findings from more developed countries which range from 13.1 to 52.2 cases per million (Chiu et al., 2010). Besides the above-mentioned studies, a systematic review identified an incidence rate of 25.5 cases per million for persons with SCI in developing countries (Rahimi-Movaghar et al., 2013). Specifically in relation to developing countries within the sub-Saharan region, incidences of 11.7 cases (Levy et al., 1998) and 13 cases per million were reported in Zimbabwe and Botswana, respectively (Löfvenmark et al., 2015). However, it should be noted that numerous factors may impact the reporting of accurate numbers with respect to this information. This may be due to the lack of adequate registries to calculate the true incidence and prevalence rates with respect to persons who have sustained a tSCI, as well as the geographical context or setting in which these studies have taken place (i.e., limited to a geographical region or facility), which in turn may overestimate or underestimate measures of tSCI frequency in these countries. Furthermore, data regarding incidence of tSCI in developing countries are minimal, which prevents the development of strategies to curb its occurrence (Furlan, Krassioukov, et al., 2010; Lee et al., 2014). From the published figures the burden of disease is high in the local South African context.

2.2.2 Prevalence of traumatic spinal cord injuries

Data regarding the prevalence of tSCI in developing countries is scarce (Wyndaele & Wyndaele, 2006) as most studies to date have been conducted in developed countries as opposed to developing countries. The prevalence rates for developed countries are relatively high, as seen in the United States of America (USA) (700-755 per million), Stockholm (223 per million), Helsinki (280 per million) and Australia (681 per million) (Wyndaele & Wyndaele, 2006). Research on prevalence data places the prevalence rate of tSCI of the USA at 906 per million, Canada at 1298 per million, Nepal at 848 per million, India at 236 per million and Iran at 440 per million (Furlan et al., 2013). However, these estimates may have changed due to preventative measures that may have been phased in after these studies were conducted. Nevertheless, no updated prevalence estimates have been published to date to corroborate any change. As noted above, those countries that have recorded higher prevalence rates may have seen this rise due to improved care systems specifically due to improved health registry systems and healthcare coverage. These have been shown to prevent early mortality, thus improving patient longevity. According to the researcher, minimal prevalence data exists in developing countries, such as South Africa. Between 2009 and 2022 only countries from Egypt (180 cases per million) (El Tallawy et al., 2013), Iran (236 cases per million) (Derakhshanrad et al., 2016), and Pakistan (5.74 per million) (Khan et al., 2018) published findings related to prevalence in developing countries. This lack of prevalence data may be due to the lack of an active SCI registry or surveillance system to track persons with SCI from time of injury to death or the lack of point prevalence data of specific health diagnoses in typical census-style studies. Furthermore, standardisation with respect to reporting of data, representativity of the sample (urban versus rural) being used and where the data originated (i.e. developed vs developing countries) are all challenges that are encountered when trying to synthesise prevalence data for SCIs (Singh et al., 2014). From the published figures in the review by Golestani et al. (2022), it is clear the burden of disease is relatively high in developing countries which, ranged from 13 (Löfvenmark et al., 2015) to 75.6 (Joseph et al., 2015) cases per million.

2.3 AETIOLOGY RELATED TO TRAUMATIC SPINAL CORD INJURIES

tSCIs could be severe injuries and are normally dependent upon the mechanism of injury (El Masri, 2006), and whether the injuries were of a high- or low-velocity nature. In sub-Saharan Africa, these injuries can be attributed to land transport accidents (32%), falls (12%), sports recreation and violence/self-harm (43%), and account for 65% of people with paraplegics and 35% of people with tetraplegia, respectively (Lee et al., 2014). A study by Joseph et al. (2015) found the main causes of tSCI to be assault (59.3%), transportation (26.3%), and fall-related aetiology (11.7%). In other developing countries such as Botswana, the main causes of injuries were noted as road traffic collisions (transportation) (68%), followed by assault (16%) and fall-related aetiology (10%) (Löfvenmark et al., 2015). A study from Tanzania further reported the main causes of SCI to be falls (48.8%), road traffic accidents (34.3%), being hit by animals or heavy landing on a person (9.4%) and assault (7.4%) (Moshi et al., 2017). When comparing the studies mentioned above, it is clearly evident that transport and fall-related aetiology were the most prevalent causes of injury in these developing contexts, with only the study by Joseph et al. (2015) conducted in South Africa noting assault as the leading cause of tSCI. This is due to South Africa's high crime rate and interpersonal violence (Harris & Vermaak, 2015). Furthermore, the study by Löfvenmark et al. (2015) attributed the substantial number of tSCI, as a result of transport aetiology, to the fact that many of the highways were single laned with high-speed limits. Additionally, it is important to highlight that the study by Löfvenmark et al. (2015) included mainly participants from the road accident fund. When comparing the aetiology of tSCI to more developed countries such as Sweden, the predominant causes were noted as falls (58%) and transport-related (40%) aetiology (Joseph, Andersson, et al., 2017). Furthermore, the only difference between developed and developing countries is the higher percentage of SCI's which is caused due to assault/interpersonal violence, which is virtually non-existent in some developed countries. In addition, road traffic accidents is the leading cause of SCI globally, however this is not the case in rural settings within developing countries where access to motorised transportation is much less(Moshi et al., 2017). As a result of the reduced access to motorised modes of transportation other causes of tSCI would therefore be more prevalent (Moshi et al., 2017)

As noted above, it is evident that the aetiology of tSCI is based on the context in which these injuries have taken place and may differ based on the socio-economic and cultural differences that are at play (Burns & O'connell, 2012). For example, a large proportion of people within the developing context are involved in jobs that require more manual labour, which may increase their risk of sustaining a tSCI (Burns & O'connell, 2012). Although not addressed in this study, one may also consider how various aspects, such as socio-economic status, may interact with aetiology in predisposing patients to early mortality (Mcgrath et al., 2019). If preventative measures can be put in place to curb some of these causes/mechanisms of injury, one could possibly see a reduction in the incidence and mortality rate. Furthermore, preventative measures can be put in place to target these causes of SCI, which would reduce the incidence and mortality rate.

2.4 MORTALITY RELATED TO TRAUMATIC SPINAL CORD INJURIES

A review of existing literature conducted in 2017 shows that mortality among developed countries ranged from 3.1% to 22.2%, compared to developing countries, where these figures ranged between 1.4% to 20% (Kang et al., 2017). Differences in mortality rates will be evident between developed and developing countries, as each country has differing healthcare structures and processes based on their access to resources (Paulus-Mokgachane et al., 2019; Pilusa et al., 2021). The above-mentioned mortality percentages in developing countries can be attributed to non-standardised means of patient monitoring. However, it is important to note that China, which is one of the largest developing countries, recorded the lowest mortality estimates. This finding could be attributed to the study's facility, as a great divide persists between rich and poor in the country (Ma et al., 2016). All studies comparing the mortality of persons with SCI to that of the general population were conducted primarily within developed countries (See Table 2.1). However, with the subsequent enhancement of medical care, there may be an improvement in these figures. Based on the literature in Table 2.1, which only included studies that reported SMR, it can be clearly seen that mortality in persons with SCI is much higher than when compared to the general population, with all studies documenting mortality that is twice that of the general population. In addition, females were reported to have a higher standardised mortality ratio compared to their male counterparts. This increased risk of mortality among female patients who sustained a tSCI may be due to the profound social and emotional changes that may negatively impact the patient's psyche following a traumatic event such as an SCI (Pentland et al., 2002). In addition, the paper by Hagen et al. (2010) reports that females had a higher standardised mortality ratio for poisoning and suicide, which is usually the result of an altered mental state (Budd et al., 2022) following an SCI. These findings support Krause's theoretical risk model assumption that psychological status can been seen as a predictor of mortality. Furthermore, the presence of secondary complication medical respiratory disease, which includes pneumonia and influenza, sepsis, neoplasms, and cardiovascular disease all contribute to increasing the patient's risk of mortality (Mckinley et al., 1999). However, they are not necessarily dependent on the patient's gender. Furthermore, these complications following injury are preventable if the necessary measures are put in place to curb their occurrence. Therefore, this highlights the need for more context specific data relating to mortality so that appropriate measures can be put in place to curb modifiable factors impacting short and long-term survival, such as secondary medical complications. As seen below, Table 2.1 provides a brief overview of the SMR with respect to the tSCI population (i.e., traumatic and non-traumatic).

Table 2.1: Mortality in spinal cord injury

Author	Title	Study design	Sample size	Country	SMR	Causes of death
(Hartkopp et al., 1997)	Survival and Cause of death after traumatic spinal cord injury A long-term epidemiological survey from Denmark	Retrospective	N: 888	Denmark (Developed)	SMR male: 2.07 SMR female: 4.9	Sepsis Pneumonia

(Frankel et al., 1998)	Long-term survival in spinal cord injury	Retrospective	N: 3179	Great Britain (Developed)	SMR by age: (0-30) - 1.99 (31-45) - 4.58 (46-60) - 1.39 (61+) - 1.37	Respiratory diseases: Pneumonia and influenza
(Yeo et al., 1998)	Mortality following spinal cord injury	Retrospective	N: 1453	Australia (Developed)	SMR: Cervical 4.0 SMR: Thoracic and Lumbar 2.4	Level of lesion Severity of lesion
(Soden et al., 2000)	Causes of death after spinal cord injury	Retrospective	N: 195	Australia (Developed)	Overall SMR:2.3	Sepsis Respiratory diseases: Pneumonia and influenza
(Garshick et al., 2005)	A prospective assessment of mortality in chronic spinal cord injury	Retrospective	N: 361	USA (Developed)	Overall SMR:1.47	Neoplasms Circulatory disorders
(Lidal et al., 2007)	Mortality after spinal cord injury in Norway	Retrospective	N: 387	Norway (Developed)	SMR male: 1.8	Respiratory disease:

					SMR female: 4.9	Pneumonia and influenza
(Hagen et al., 2010)	Mortality after traumatic spinal cord injury: 50 years of follow-up	Retrospective	N: 401	Norway (Developed)	SMR male: 1.72 SMR female: 2.88	Respiratory disease
(Ahoniemi et al., 2011)	Survival after spinal cord injury in Finland	Retrospective	N: 1647	Finland (Developed)	SMR male: 2.54 SMR female: 3.56	Cardiovascular disease Suicide
(Sabre et al., 2013)	Mortality and causes of death after traumatic spinal cord injury in Estonia	Retrospective	N: 595	Estonia (Developed)	SMR male: 2.70 SMR female: 3.80	Cardiovascular disease Suicide

SMR = Standardised Mortality Ratio

2.5 RECOMMENDATIONS FOR TSCI MANAGEMENT IN THE ACUTE CARE SETTING

Optimal health systems endeavour to provide effective and timely care to persons who have sustained traumatic injuries. These systems allow for care to be delivered promptly to improve neurological outcomes of patients who have sustained a tSCI. In pursuit of improving health outcomes for persons who have sustained tSCI, specialised centres of care have been developed to improve the quality of care being delivered. These specialised care units include evidence-based characteristics in terms of the structure and process of care that have been shown to decrease mortality, prevent the occurrence of secondary conditions and reduce the length of hospital stays (Parent et al., 2011). Furthermore, this system of specialised care does not stop within the hospital setting but continues post-discharge, which improves the patient's probability of returning home and resuming their roles both at home and in society (Cheng et al., 2017). For these units to function optimally, they should include a wide range of clinicians with expertise and training in the management of tSCI, which has been shown to lead to improved patient outcomes (Maharaj et al., 2017). Sir Ludwig Guttman established the first of such specialised SCI units in 1944 in Aylesbury, England (Parent et al., 2011). Subsequently, developed countries such as Norway, Sweden, Netherlands, Italy, Portugal and the United States of America have followed this approach and have specialised means of care for patients who have sustained a tSCI (Baricich et al., 2017; Campos et al., 2017; Post et al., 2017a; Richards et al., 2017; Strom et al., 2017). Although this system of care has proven benefits, established SCI units in the government sector and those that are in the process of being implemented may experience many challenges. Some of these challenges may pertain to, but are not limited to:

- unequal distribution of resources (public versus private);
- management and leadership crisis (mismanagement of state healthcare facilities);
- increased disease burden (multiple burdens of disease); and
- slow progress in restructuring the healthcare system (Maphumulo & Bhengu, 2019).

Irrespective of the challenges, a systematic and guided approach to managing these patients remains important. In this regard, a recent study by Burger and Christian (2020) has shown that a noticeable difference in the availability of healthcare services exist between urban (85%) and rural setting (60%). Furthermore, this difference between urban and rural settings also translates to the accessibility of healthcare service (Booysen, 2003).

In 2002, the American Association of Neurological Surgeons developed a set of guidelines (see Table 2.2 below) to manage patients with acute SCI in an evidence-based manner to improve patient outcomes. This set of initial recommendations was then subsequently updated in 2013, considering new evidence regarding patient management (Walters et al., 2013). During this same period, the Consortium of Spinal Cord Medicine also published its own set of clinical guidelines (Consortium for Spinal Cord, 2008). In addition to the much larger societies publishing guidelines, further research such as those conducted by Fehlings, Tetreault, Wilson, Kwon, et al. (2017) also developed clinical guidelines to manage persons with acute SCI better. However, a large proportion of recommendations, specifically relating to Fehling's set of guidelines, were graded as relatively low to weak based on their Graded Recommendation Assessment Development and Evaluation (GRADE) scores (Fehlings, Martin, et al., 2017; Fehlings, Tetreault, Aarabi, et al., 2017). These weak to low scores were primarily due to the lack of rigorous research specifically addressing topics relating to the timing of rehabilitation and diagnostic imaging (Fehlings, Martin, et al., 2017; Fehlings, Tetreault, Aarabi, et al., 2017).

Based on the findings from Fehling's research, more rigorous and high-quality evidence is needed if we wish to recommend certain interventions or processes in persons with

SCI. A positive to take from this is that researchers have been actively prioritising key clinical questions that seek to facilitate managing persons who have sustained tSCI. Although these clinical guidelines are important for patient management, they may not necessarily apply to the South African context; hence they cannot be adopted without taking into account our country's healthcare system and context-specific barriers. To date, no formalised standard management guideline for tSCI management exists within the South African context, impacting how care is designed, implemented, and evaluated. The table below highlights the key process measures clinical guidelines consistently make reference to, and which will be relevant to this study based on their evidence backing. This list was constructed by conducting a limited literature search for all available acute care guidelines in the management of persons who sustained a tSCI. The extent to which the following processes are followed in the local context remains unknown.

Table 2.2 Recommendations based on key process measures in the management of persons with tSCI.

Process measures	Recommendations	Quality of evidence
Pre-hospital management	• *"On arrival at the scene of the incident, use a prioritising sequence to assess people with suspected trauma, for example, ABCDE" (Uk National Clinical Guideline Centre, 2016).* • *"Protect the person's cervical spine with manual in-line spinal immobilisation, particularly during any airway intervention and avoid moving the remainder of the spine."* • *"EMS providers should use the combination of rigid cervical collar immobilisation with supportive blocks on a backboard with straps or similar device to secure the entire spine of patients with potential spinal injury" (Consortium for Spinal Cord, 2008).* • *"According to the literature, patients should be immobilised before transport to the hospital using a cervical collar, head immobilisation and a spinal board" (Fehlings et al., 2011).*	• ***(Scientific evidence–I/II; Grade of recommendation–A; Strength of panel opinion–5)***

	• *"All trauma patients with a cervical spinal column injury or with a mechanism of injury having the potential to cause cervical spine injury should be immobilised at the scene and during transport by using 1 of several available methods" (Hadley and Walters 2013).*	
Spinal surgery	• *"Consider early surgical spinal canal decompression in the setting of a deteriorating spinal cord injury as a practice option that may improve neurologic recovery. However, there is no compelling evidence that it will. Consider early spinal stabilisation where indicated" (Consortium for Spinal Cord, 2008).* • *"Early surgical intervention (8-24hr) should be considered following acute tSCI" (Fehlings et al., 2011).* • *"Early surgery be offered as an option for adult acute SCI patients regardless of level" (Fehlings, Tetreault, Wilson, Aarabi, et al., 2017).*	• ***(Scientific evidence–II/III/IV; Grade of recommendation–B; Strength of panel opinion–5)*** • ***(Quality of evidence - Low; Strength of recommendation: Weak)***

Associated injuries evaluation	• *"Complete a comprehensive tertiary trauma survey of the patient with potential or confirmed spinal cord injury" (Consortium for Spinal Cord, 2008).*	• ***(Scientific evidence - II/III/IV; Grade of recommendation–B; Strength of panel opinion–5)***
Specialised SCI care	• *"Outcomes can be improved by management in specialised centres with access to intensive care units" (Fehlings et al., 2011).* • *"Transfer the patient with a spinal cord injury to a Level I trauma centre as soon as possible, as defined by the American College of Surgeons or by state statute. Given local triage protocols and guidelines relating to transportation times to trauma centres, consider taking the patient directly to a Level I centre if possible, in preference to passing through a Level II or III centre first" (Consortium for Spinal Cord, 2008).*	• ***(Scientific evidence - II/III/IV; Grade of recommendation–B; Strength of panel opinion–5)***
Multidisciplinary team	• *"For people in a trauma unit who have a spinal cord injury, the trauma team should immediately contact the specialist neurosurgical or spinal surgeon on*	

	call in the trauma unit or nearest major trauma centre" (Uk National Clinical Guideline Centre, 2016). • *"For people who have a spinal cord injury, the specialist neurosurgical or spinal surgeon at the major trauma centre or trauma unit should contact the linked spinal cord injury centre consultant within 4 hours of diagnosis to establish a partnership of care" (Uk National Clinical Guideline Centre, 2016) (Specialist neurosurgeon or spinal surgeon).* • *"Rehabilitation be offered to patients who sustained acute spinal injury when they are medically stable and can tolerate required rehabilitation intensity" (Fehlings, Tetreault, Aarabi, et al., 2017).* • *"Assess mental health in general and possible risk for psychosocial problems after admission and throughout acute care stay. Involve members of the health-care team as needed." (Consortium for Spinal Cord, 2008) (Psychologist and Social worker).*	• ***(Quality of evidence - No included studies; Strength of recommendation: Weak)*** • ***(Scientific evidence - NA; Grade of recommendation–NA; Strength of panel opinion–5)***

	• *"Provide appropriate nutrition when resuscitation has been completed and there is no evidence of ongoing shock or hypoperfusion"(Consortium for Spinal Cord, 2008). (Dietician).*	• ***(Scientific evidence–III/IV; Grade of recommendation–C; Strength of panel opinion–5)***
Secondary complications prevention	• *SCI patients are at a significant risk of cardiovascular and respiratory problems, and management should proactively anticipate these potential complications (Fehlings et al., 2011).*	
Length of acute care	• *"Develop appropriate guidelines evaluating and transporting patients with potential spinal cord injuries based on local resources. Identify regional trauma centres with special resources for the acute management of spinal cord injuries"(Consortium for Spinal Cord, 2008).* • *Consider directing spinal cord–injured patients expeditiously to a specialised spinal cord injury*	• ***(Scientific evidence–III/IV; Grade of recommendation–C; Strength of panel opinion–5)***

	centre that is equipped to provide comprehensive, state-of-the-art care. Discuss pretransfer requirements with the referral centre (Consortium for Spinal Cord, 2008).	• ***(Scientific evidence–I/II/III/IV; Grade of recommendation–A; Strength of panel opinion–5)***
Rehabilitation	• *"Develop protocols that allow rehabilitation specialists to become involved early in the management of persons with SCI, immediately following injury during the acute hospitalization phase" (Consortium for Spinal Cord, 2008) (Physiotherapist and Occupational therapists).* • *"That rehabilitation be offered to patients who sustained acute spinal injury when they are medically stable and can tolerate required rehabilitation intensity" (Fehlings, Tetreault, Aarabi, et al., 2017).* • *Research however still remains minimal.*	• ***(Scientific evidence–NA; Grade of recommendation–NA; Strength of panel opinion–5)*** • ***(Quality of evidence - No included studies; Strength of recommendation: Weak)***

**** N/A: Not applicable; EMS: Emergency medical services; Level I: High quality randomised controlled trial with statistically significant difference or no statistically significant difference but narrow confidence intervals, systematic review of level I randomised controlled trials (studies were homogenous) Level II: Lesser quality randomised controlled trials (e.g., <80% follow-up, no blinding , or improper randomisation), prospective comparative study; systematic review of level II studies or level I studies with inconsistent results: Level*

III: case control study, retrospective comparative study, systematic review of level III studies; Level IV: case series; GRADE A: The guideline recommendation is supported by one or more level I studies; GRADE B: The guideline recommendation is supported by one or more level II studies; GRADE C: The guideline recommendation is supported only by one or more level II, IV, or V studies; Level of panel agreement 5: Strong (mean agreement score = 3.67 to 5)

2.6 SCI MANAGEMENT IN SOUTH AFRICA

Although South Africa's pre-hospital/trauma services have improved over the years, it is not at a point where it should be, as we are still addressing the inequalities and disparities of the past as a result of apartheid (Brauns & Stanton, 2016). Public facilities within South Africa serve approximately 80% of the general population, with only 20% having access to private medical aid services (Goosen et al., 2003). Apartheid played a role with respect to how our healthcare systems were set up, highlighting vast discrepancies in the quality of care and issues of healthcare equality. Healthcare facilities are predominantly situated within urban areas, while facilities situated in rural areas were put in place to provide healthcare service to ethnic groups such as blacks, coloureds and Indians. As a result of the past inequalities, with respect to our health system, we are not at the point of attaining an optimal healthcare system that allows for improved patient-centred care, as all specialised services are found in urban areas. This disparity still exists today, where people residing in rural settings are required to travel long distances to receive generalist care, let alone specialised care, which has been shown to improve patient prognosis (Mclaren et al., 2014). Due to the long distances these patients are required to travel, the critical period in which surgeries can be performed will be missed and may negatively impact the patient's diagnosis (Ahuja et al., 2020), leading to premature death. These long travelling distances required to receive specialised care result in delayed hospital admission (Frielingsdorf & Dunn, 2007), and a number of intermediate hospitalisations that are not always beneficial. Currently, the pre-hospital time in South Africa is believed to be in the region of 2 hour, which is relatively long if time is of essence when handling trauma-related injuries (Goosen et al., 2003). Patients are currently managed by only a select number of specialised centres equipped to manage persons with tSCI. Ideally, those who have sustained a major trauma such as a tSCI should be transferred to a level one trauma facility. However, many present to district healthcare facilities that are not adequately equipped to handle major traumatic injuries (Goosen et al., 2003). This raises the question of whether emergency medical services (EMS) possess the requisite expertise to screen for potential SCI, or whether sufficient bed space exists to manage these patients within an acute setting (Naidoo & Naidoo, 2021; Netshisaulu et al., 2019; Sothmann et al., 2015). In addition, patients who did not meet strict entry requirements may not receive the much-needed specialist inpatient /outpatient rehabilitation services that have been shown to improve patient outcomes. Although the above-mentioned challenges may still exist (Maphumulo & Bhengu, 2019), the introduction of a primary healthcare system post-apartheid has helped to provide more equitable access of care to patients (Naledi et al., 2011). However, within the context of acute SCI, few patients benefit from primary healthcare at the onset of their injury but do so later in their recovery process.

Further challenges, such as prolonged waiting times for patients; increased litigation of avoidable medical errors; adverse events; poor hygiene and infection control measures; poor record keeping and shortages in medicine and resources, further hinder the provision of acute care for these patients (Maphumulo & Bhengu, 2019).

Secondary medical complications remain relatively high within the acute phase (Joseph & Wikmar, 2016), which may negatively impact patient survival. In addition, persons who sustained a tSCI due to gunshot-related aetiology were found to have longer hospital stays coupled with frequently occurring secondary medical complications (Joseph, 2017). Furthermore, these secondary medical complications, such as pressure ulcers, are preventable (i.e., modifiable) and may increase the length of hospital stay. Research within the local context has proven that mortality is relatively high in the long term for persons with tSCI following discharge with a high prevalence of otherwise preventable secondary complications (Madasa et al., 2020). This high prevalence of secondary medical complications further increases the likelihood of patients being readmitted after they have been successfully discharged (Mashola et al., 2019). In addition, these increased readmission rates further overburden an already struggling healthcare system.

2.7 KRAUSE'S THEORETICAL RISK AND PREVENTION MODEL

As seen in Figure 1.1, Krause's theoretical risk model was developed in 1996to prevent early mortality and assist in the preventing the development of secondary health complications in persons who have sustained SCI. Furthermore, it sought to improve patient outcomes by identifying those factors which cause ill health or even increase a patient's likelihood of early mortality (Krause, Saunders, Dipro & Reed 2014). In the pursuit of identifying these predictors of early mortality in patients who sustained tSCI's Krause et al. developed a theoretical risk model (Figure 2.1), which consists of four domains namely: basic biographic and injury factors; health factors; behavioural factors; psychological and environmental factors (De Vivo, Stuart Krause, & Lammertse, 1999; Krause, Sternberg, Lottes, & Maides, 1997; Krause, Carter, Pickelsimer, & Wilson, 2008; Krause, Zhai, Saunders, & Carter,2009; Krause, Saunders, DiPiro, & Reed, 2013). In this theoretical risk model, demographics and injury characteristics were used as controls/mediators due to the direct involvement of these variables in mortality (Krause, Saunders, Dipro & Reed 2014). It was also found that many non-clinical factors, such as health behaviour and psychological status, were important predictors in determining early mortality or the development of secondary complications. Hence, factors such as socio-economic and socio-environmental status, psychological status and health behaviour are, at times, crucial predictors in determining early mortality in persons who have sustained a tSCI (Øderud, 2014). The aforementioned variables are modifiable, which means that if the objective is to decrease mortality to improve survival rates, we need to employ the necessary preventative measures towards these modifiable factors, such as health behaviour, which could include aspects of physical activity, psychological status and current physical environment (Cao et al., 2013; Krause et al., 2008). Recent studies have shown how the identification of psychological risk factors may assist in preventing cause-specific mortality of persons who have sustained spinal cord injuries (Cao et al., 2019). Hence, intervening in the patient's health behaviour, psychological status and environment will directly impact on the health factors that the patient may encounter. Furthermore, targeting the "high-risk" patients earlier rather than later will decrease the probability of early mortality and improve survival rates among this specific cohort of patients as additional resources may be directed to this vulnerable grouping of patients. By identifying and narrowing down clear predictors of early mortality, one would be able to determine which patients should receive more intensive care to improve their probability of survival. For this research study, Krause's theoretical risk model will be used when assessing the factors (exposures) contributing to mortality. However, these factors will only be selected based on the following criteria: i) strongest evidence arising from the rapid review (i.e., Chapter 3) and ii) whether these factors are contextually relevant and measurable in the current healthcare system of South Africa. However, this risk model does not assess the impact of healthcare care processes on mortality; hence, Donabedian's model of care (Figure 2.2) will be used to assess its impact. This was achieved by determining which key process measures were consistently present in the acute care guidelines identified in Chapter 2 (See Table 2.2) and ii) whether these process measures are contextually relevant and measurable in the current healthcare system of South Africa.

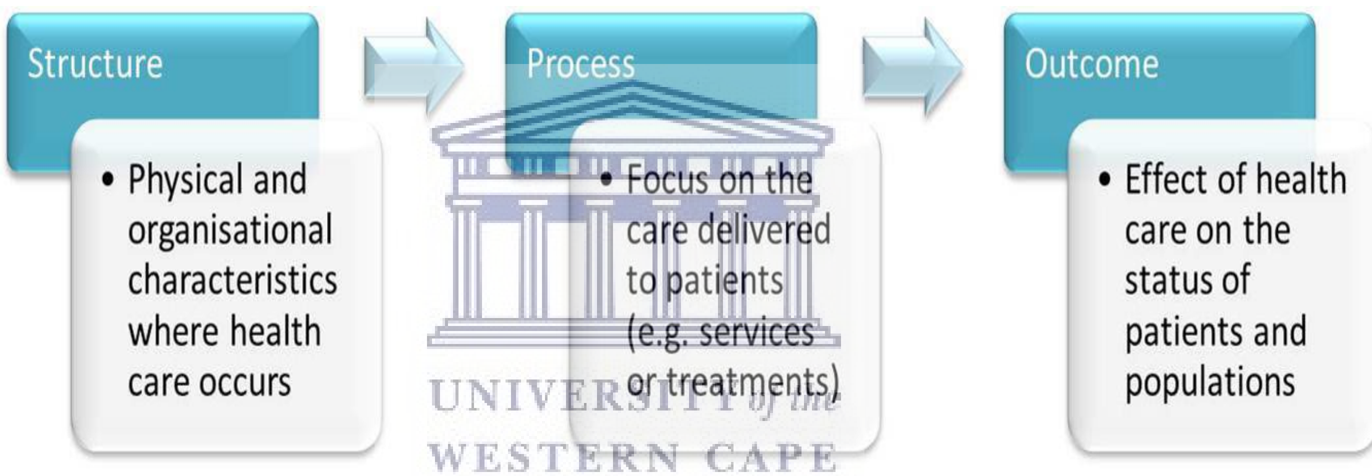


Figure 2.1: Donabedian's conceptual model of care

Donabedian's quality of care model is used to identify any changes in the processes of care to improve patient outcomes and is one of the most widely used models to assess care processes within healthcare structures (Mitchell et al., 1998). As stated earlier, the process of care reflects appropriate interventions, timing and dose. This means that if quality evidence-based interventions are not administered at the right place and time, it may likely reduce the patient's probability of survival. Conversely, the structure of care relates to specialist units which are in place to manage persons with tSCI's. This model leans towards the understanding that the structure and process influence outcome; however, outcomes obtained in medical care are not fully explained by the inputs alone, and hence the inclusion of risk factors as operationalised by Krause's model improves the ability to understand better what contributes to survival (Donabedian, 1966). As seen in Krause's theoretical risk model various factors such as psychological status, protective and risk behaviour, socio-environmental status, and secondary conditions /global health are not factored into Donabedian's model care but play an integral part in determining which patients might be at a higher risk of mortality. Therefore, factors affecting mortality should be seen through the lens of the system providing that care (Donabedian's model of care) and the factors which the patient bring to this system (Krause's theoretical risk model).

Multiple factors are at play when assessing the mortality of patients who have sustained a tSCI, be it during the acute or post-discharge of the patient (Hagen et al., 2010; Øderud, 2014; Varma et al., 2010) However, knowing which of these factors are strong candidate factors are key if we wish to improve patient-specific outcomes such as survival.

2.8 USE OF CLINICAL PREDICTION RULES TO IMPROVE PROCESS MEASURES

Novice clinicians often struggle with decision-making processes due to their lack of experience, especially decisions regarding high-risk patients, which are predominantly made subjectively, or by means of expert opinion (Smith, 2008). The latter is not ideal since many factors that influence one's decision-making process, such as values/norms and work experience (Smith, 2008). Clinical prediction rules (CPR) may be used to improve evidence-based decisions regarding care to improve patient prognosis. Therefore, using a CPR facilitates the evidence-based medicine approach, such as acute care guidelines (Consortium for Spinal Cord, 2008; Fehlings, Tetreault, Wilson, Kwon, et al., 2017; Walters et al., 2013). By determining predictors of early mortality, one could contribute to developing a healthcare decision-making model or guideline based on empirical evidence that could improve the survival of persons with tSCI following an injury. However, a distinction must be made between CPRs and decision-making tools as the way impact is assessed differs. CPRs predict a relevant outcome, while the impact of clinical decision-making tools can only be assessed by the extent to which the CPR affects decision-making processes to improve patient outcomes (Reilly & Evans, 2006). These forms of decision-making models are merely a way for healthcare practitioners to make an informed decision to address certain clinical questions that may need to be answered. It is further used to identify patients need scarce treatments and interventions, and to allocate of resources within the clinical setting (Kennedy & Gallego, 2019). In addition, using healthcare care decision-making models, such as CPRs, are useful in ensuring quality improvement in the care that is being delivered, identifying environmental factors that need to be considered, and developing CPRs (Bae, 2014).

CPRs are being actively researched within the field of SCI, however, these CPRs have primarily been developed to predict patient function following an SCI (Facchinello et al., 2017; Kaminski et al., 2017; Van Middendorp et al., 2011; Wilson, Grossman, et al., 2012). Although being able to predict function after an injury is important, it is even more important to determine which patients would be at an increased risk of reduced survival so that a more intensive care package may be directed to these patients, as opposed to redirecting resources away from those who have a lower chance of survival. Rarely do these crude prediction tools reach the validation and impact analysis phase of model development (Vaillancourt et al., 2011), which is a loss as there is always an opportunity to improve the quality of care that is delivered to patients. For a CPR to be used within the clinical setting, it needs to undergo four steps:

- **Step one**, otherwise known as *Derivation*, entails identifying those factors that have a high predictive power regarding the outcome of interest (Adams & Leveson, 2012).
- **Step two**, otherwise known as *Validation* (broad and narrow), determines whether the model works in the setting within which the tool was developed and other clinical settings (Adams & Leveson, 2012).
- **Step three**, otherwise known as *Impact Analysis* assesses usefulness within the given clinical setting concerning resource allocation and cost-effectiveness (Adams & Leveson, 2012).
- **Step four**, which is referred to as the *Implementation stage* and involves adopting the tool within the clinical setting (Adams & Leveson, 2012).

Only two prediction models have been developed to date that specifically address the aspect of survival in persons with SCI (Fallah et al., 2022; Hossain et al., 2019). Both prediction models have undergone the validation process but still need to undergo the impact analysis and implementation stage. These final two steps are seldom possible due to challenges that may arise concerning the readiness for implementation as well as the design and analysis of the impact study (Kappen et al., 2018). Being able to predict survival in low-middle-income countries (LMIC) such as South Africa allows one to successfully stratify patients into high- or low-risk groupings, which is necessary especially within the South African context that is a resource constrained environment. This stepwise approach to developing a CPR is applicable to South Africa, however, challenges may be experienced with respect to identifying predictors of mortality due to a non-existent national patient registry. Furthermore, challenges may be encountered with the implementation of such rules owing to clinician's preferences with respect to patient management. The latter is however an obstacle that is experienced in both developed and developing countries.

2.8.1 Models of clinical prediction tool development

Various methods of clinical prediction exist to inform clinician practices. As outlined below, Grobman and Stamilio (2006) identified five methods (i.e., scoring systems, nomograms, classification, regression trees and neural networks) that are commonly used within the medical literature. These methods are primarily based on univariate or multivariate analysis, neural networks, nomograms and decision trees/CART analysis:

- **Scoring systems:** *"In this method, associations between categoric variables and a clinical outcome are ascertained through the use of univariable statistical tests such as the Student t test and chi-square analysis (Grobman & Stamilio, 2006)."*

- **Nomograms:** "*Nomograms allow for the accounting of the interactive effects of multiple independent variables and present these interactions in a graphic form that is accessible to clinicians (Grobman & Stamilio, 2006).*"
- **Regression trees:** *"Multivariable techniques such as logistic regression allow for the improved assessment of the association of each independent variable with the dependent outcome (Grobman & Stamilio, 2006)."*
- **Decision trees: "***CART analysis is another type of predictive model that uses nonparametric techniques to evaluate data, account for complex relationships, and present the results in a clinically useful form (Grobman & Stamilio, 2006)."*
- **Machine learning algorithm (MLA):** *"A neural network seeks to account for the complex nonlinear relationships of independent variables with one another and with the dependent variable as well (Grobman & Stamilio, 2006)."*

Each of the above-mentioned models of clinical prediction has limitations concerning its design and application to the clinical setting. However, it is important to use a model that fits the end user of the model well, as they will be using it daily to inform their practice. If not compatible and user friendly to their practice or setting, one would find a definite lag in its uptake. The most common model used to inform decision making tools to date is a regression framework (Bonnett et al., 2019).However, there has been a gradual move towards using neural networks when predicting patient-specific outcomes related to this group of patients.

However, as technology improves and clinicians/researchers explore alternative means of improving care for these patients, innovative ways, such as the use of MLA, have been used in predicting patient outcomes related to persons who have sustained an SCI (traumatic and non-traumatic) (Khan et al., 2019). However, there is more reliance on research decision-making tools that incorporate logistic regression as opposed to MLA, as the former is well-researched in the literature while the latter is relatively new (Khan et al., 2019). The use of MLA also has noticeable advantages compared to their regression model counterparts. These advantages relate specifically to the fact that no prior knowledge of predictors is required, there is no cap on the number of predictors that can be used in the model, and algorithms are capable of picking up on complex relationships (Khan et al., 2019). Due to the nonexistence of a national registry, there is insufficient data to input into models that employ a machine learning approach. These algorithms usually identify predictors based on the availability of large datasets absent in South Africa.

Although the above-mentioned models may be useful in predicting the probability of survival of those patients who are at a higher risk of mortality, they do not tell us what can be done to improve survival. Prediction will merely tell us what would happen if a patient presents with a set of variables that may place them at a higher risk of mortality (i.e., predicting the mortality rate of persons with SCI will not give you the information as to how mortality can be reduced). Hence, the use of an explanatory/descriptive model (Shmueli, 2010), as opposed to a predictive model, should be used if we wish to improve the care pathway in which these patients are managed. Moreover, as this type of modeling will provide us with the necessary information needed to change care processes which may negatively impact patient survival. Furthermore, the use of an explanatory/descriptive model seeks to discuss the relationships that may exist between variables, thus explaining the possible reasons for increased mortality amongst these patients. This, however, is not the case when using a predictive model as casual relationships between variables will be ignored as inferences will be solely made based on the available data. Therefore, for the purposes of this study, an explanatory/descriptive model approach will be used to better understand inputs of mortality. It therefore will lead to unlocking what should be considered and measured.

2.8.2 Presentation of decision support tool

The use of evidence-based practice also has its noticeable challenges. Methodologically rigorous tools may be developed; however, they may not be adequately implemented due to aspects of clinical practicality being considered. If these tools are not practical and simplistic clinicians will experience difficulties in their implementation. As each clinical context differs from the next, it is important to engage with those healthcare practitioners that will be using the tool thereby ensuring its uptake (Bonnett et al., 2019) . The reduced or simplified version of the prediction tool should undergo the same testing as would be the case for the full regression model. This is to ensure that the psychometric properties related to the use of the tool is sufficiently rigorous. In addition, Bonnett et al. (2019) found the following presentation means most appealing when presenting decision support tools: a point score system; a graphical score chart, a nomogram and a website/application Furthermore, each presentation style has its own noticeable advantages and disadvantages, hence context will always remain key when deciding how the final decision support tool should be presented within the clinical setting to facilitate its uptake. However, with technological advances there may be a point at which these tools are used on an online platform which will allow researchers to evaluate data in real time.

2.9 CONCLUSION

In conclusion, not much is known regarding the mortality rate of persons with SCI in developing countries such as South Africa, as majority of the published evidence comes from developed countries. Accurate and reliable data pertaining to SCI within developing countries, still hampers the development of appropriate preventative measures concerning injury prevention and secondary-level effects, such as medical complications, activity limitations and participatory restrictions. As noted above, the lack of evidence on measures of injury frequency are due to the lack of a standardised approach in monitoring patients with SCI in LMIC, such as South Africa. If a standardised approach is put in place, one would get a better idea with respect to the overall burden of tSCI within the South African context. Accurate and up-to-date prevalence data will further assist in restructuring our current healthcare context to better manage these patients by targeting factors that may directly impact survival. Therefore, this study seeks to add to the epidemiological profile of existing literature regarding tSCI within the Cape Metropolitan area. Furthermore, it will provide an overview of SCI care in South Africa, as it appears that numerous suggestions point to the fact that specialised care is not fully operational and opportunities to strengthen this philosophy and implementation remain plentiful.

Currently, CPRs are exclusively being used to predict function in persons who have sustained tSCI, however, a dearth of CPR used to predict survival still exists, with only two such CPRs being developed to date. Hence, this study seeks to contribute to the development of a predictive rule that is contextually relevant, and is focused on improving survival for persons who have sustained a tSCI. Lastly, this study also seeks to provide rigorous data on time-sensitive interventions in the patient's pathway of care which can be used in the developing a contextually relevant set of clinical guidelines, as none exist to date for our context.

CHAPTER THREE: RAPID REVIEW

PREDICTORS OF EARLY MORTALITY

3.1 INTRODUCTION

The rapid review aligns with objective 1.5.3, which set out to determine the predictors of early mortality for persons who sustained a traumatic spinal cord injury (tSCI). The findings of this review were used to inform the selection of candidate exposures which were, firstly, included in the design of the methods of this study and, secondly, may be linked to the mortality cases in Chapter 6. With the adoption of Krause's theoretical model and the limited guidance from clinical prediction tools for mortality in spinal cord injury (SCI), there is a need to identify rigorous factors, both modifiable and non-modifiable, that impact survival from the literature. This chapter employed a rapid review methodology as set out by Tricco et al. (2017) to identify these factors. The rapid review methodology includes the followings steps:

- protocol development;
- literature search;
- screening and study selection;
- data extraction;
- risk of bias assessment; and
- knowledge synthesis.

Furthermore, this chapter provides an overview of the characteristics of the included studies, which reported on independent predictors of early mortality (i.e., from injury onset to one-year post-injury) that may impact patient survival. These independent predictors were chosen based on their relevance to the context and their ability to be measured or screened in the current healthcare system as part of routine care, i.e., to understand the system as it is before proposing changes. Furthermore, these independent predictors were integral in identifying candidate exposures (i.e., factors which influencing early mortality) that may be linked to acute management and early mortality. Krause's theoretical risk model and Donabedian's model of care, which specifically addressed the aspects of process measures, were used as guiding frameworks in this chapter.

Predictors related to personal factors included demographical (i.e., age and gender) information, while injury factors included all baseline injury characteristics. on the other hand, process factors included time-sensitive interventions, transfer logistics and screening for pre-existing comorbidities and secondary medical complications. Lastly, the chapter discusses the main findings of the included studies related to risk factors associated with and predictive of poorer survival outcomes within the first year post-SCI.

3.2 RAPID REVIEW METHODOLOGY

The rapid review methodology used in this chapter was guided by that of Tricco et al. (2015) and Tricco et al. (2017).As mentioned above, the primary reason for conducting this rapid review was to identify the candidate exposures, which may place persons who have sustained a tSCI at a higher probability of reduced survival. It was decided not to employ a systematic review methodology. This is because of the complexity and magnitude of the factors associated with mortality and morbidity and the fact that each factor would need to have been studied separately, provided that sufficient quality of studies was available.

3.2.1 Search strategy

The following search terms were used to identify potentially relevant studies for inclusion in this rapid review: *"traumatic spinal cord injury "*AND *"predictors"* AND *"mortality"*. It is important to note that a distinction must be made between risk factors and predictors, as all risk factors will not necessarily be predictors of mortality. Hence, the reason why the search term "predictors" was only used in the context of this rapid review. Although survival and mortality are sometimes used interchangeably, they are calculated and defined differently and influenced by varying factors. Therefore, the researcher decided only to use the term "mortality". The following databases were searched Ebscohost - (Medline; Academic search complete and Cinahl Plus) and SCOPUS. The search limits set for each database were language i.e., only English studies were included. These databases were searched individually by one reviewer (i.e., the researcher) while the main supervisor conducted a random check of the search results. The researcher performed independent "pearling / snowballing" of potentially relevant articles for inclusion in the review while the main supervisor did a random check of the reference lists to ensure no relevant articles were omitted from the review. The main supervisor was consulted if the researcher could not decide whether the article should be included in the review or not. Contacting authors of literature was not considered, as this step does not routinely form part of the rapid review process (Tricco et al., 2017).

3.2.2 Study selection

One reviewer independently performed a screening of titles and abstracts. After titles and abstracts were screened, a list of potentially relevant articles was created. This list of potentially relevant articles was then subjected to the inclusion and exclusion criteria mentioned below. Studies that met the inclusion criteria were included in the rapid review.

The inclusion criteria for this review were as follows:

- the studies should include participants who have sustained tSCI;
- participants in the studies should be >18 years;
- studies published in English only;
- studies that were published from database inception till 2020;
- all study designs were considered (i.e., experimental and non-experimental) and systematic reviews;
- studies that assessed predictors for early mortality (as mentioned earlier, early mortality was defined as the date from the onset of injury to one-year post-injury). Studies were excluded from this review if they were (1) poster presentations and (2) no full-text articles were available for screening.

3.2.3 Data extraction

A single reviewer performed data extracted from included studies. As per the literature search process, the main supervisor verified the extracted data (i.e., no more than 10% of the included studies). A self-adapted data extraction form based on the Joanna Briggs institutes was used to obtain all relevant information related to this review. A piloting phase was done to ensure all relevant aspects of the included studies were extracted: authors' details, year of publication, country, study type, aim/purpose of study, sample size, factored-in confounding, mechanism of injury, independent predictors of early mortality.

3.2.4 Quality appraisal

Quality appraisal of included studies were not performed as the purpose of this rapid review was to scope the available literature relating to predictors of early mortality rather than to determine the overall effectiveness of individual predictors within the clinical setting. Furthermore, this decision was in line with four of the six rapid review approaches as outlined by Tricco et al. (2017).

3.3 RESULTS

The following databases were searched from database inception to the end of July 2020 (see Figure 1): Ebscohost (Medline; Academic search complete and Cinahl Plus) = 38 articles, and SCOPUS = 19 articles. These databases were chosen as they are the most widely searched/used databases. The pearling of reference lists yielded an additional nine articles, bringing the total to 66 articles. After duplicates were removed (n=22), 42 articles were screened against the eligibility criteria. After screening titles and abstracts, 17 articles were excluded for not referring to predictors or early mortality. An additional 11 articles were then excluded for not meeting the inclusion criteria. This left 16 articles which were included in the review.

As seen in Table 3.1 majority of the research was conducted in Canada (5 articles) and the United States of America (4 articles), respectively. The remaining studies were from Iran (1 article), Australia (2 articles), Saudi Arabia (1 article), Brazil (1 article), Japan (1 article) and France (1 article). Fifteen of the sixteen studies used a retrospective design to identify key early mortality predictors, while only one study (Daverat et al., 1989) used a prospective study design.

The main independent predictor of early mortality was age. Nine (Alsaleh et al., 2017; Banaszek et al., 2020; Claxton et al., 1998; Daverat et al., 1989; Furlan & Fehlings, 2009; Inglis et al., 2020; Shibahashi et al., 2019; Tee et al., 2013; Varma et al., 2010) of the fourteen studies reported on age. Of the nine studies which reported on age, eight (Alsaleh et al., 2017; Banaszek et al., 2020; Claxton et al., 1998; Daverat et al., 1989; Furlan, Bracken, et al., 2010; Inglis et al., 2020; Tee et al., 2013; Varma et al., 2010) of these studies found age to be an independent predictor of early mortality of persons who sustained tSCI. The above studies proved that an increase in patient age increased the odds of early mortality.

The second most common predictor after age was neurological level /deficit. Eight (Alimohammadi et al., 2020; Alsaleh et al., 2017; Bokhari et al., 2019; Claridge et al., 2006; Claxton et al., 1998; Daneshvar et al., 2013; Neumann et al., 2009; Tee et al., 2013) of the included studies reported on neurological levels/deficit. However, only five (Bokhari et al., 2019; Claxton et al., 1998; Daneshvar et al., 2013; Inglis et al., 2020; Varma et al.,

2010) of the seven studies found the severity or the level of injury to be independently predictive of mortality. These studies proved that patients with a higher neurological level of injury, or deficit, were at an increased likelihood of early mortality.

Lastly, the third most common predictor related to the presence of comorbidities. Only six studies (Alimohammadi et al., 2020; Alsaleh et al., 2017; Bokhari et al., 2019; Inglis et al., 2020; Tee et al., 2013; Varma et al., 2010) reported on the presence of pre-existing comorbidities with only five (Alsaleh et al., 2017; Bokhari et al., 2019; Inglis et al., 2020; Tee et al., 2013; Varma et al., 2010) proving that the presence of multiple comorbidities is considered an independent factor to early mortality. The following were found to be independent predictors of mortality but were not as common as those stated above: the mechanism of the injury; physiological parameters; access to a level one trauma; centre; pharmacological intervention, and secondary complications.

These independent predictors in Table 3.1 were further grouped into either modifiable or non-modifiable predictors of mortality, with most predictors being classified as non-modifiable. Modifiable factors are those clinical variables that can be changed, while non-modifiable factors are those that cannot be changed. Regarding gender, all studies had a larger proportion of male than female participants. The leading causes of injury with respect to the included studies were either transport or fall-related. The percentage of in-hospital mortality ranged from 7.7% (Claridge et al., 2006) to 48% (Tee et al., 2013). All studies except one (Daneshvar et al., 2013) controlled for confounding variables during the computation of regression models. The reason the one study did not factor in confounding was due to the small sample size, which prevented the authors from performing any subgroup analysis or multivariable regression analysis.

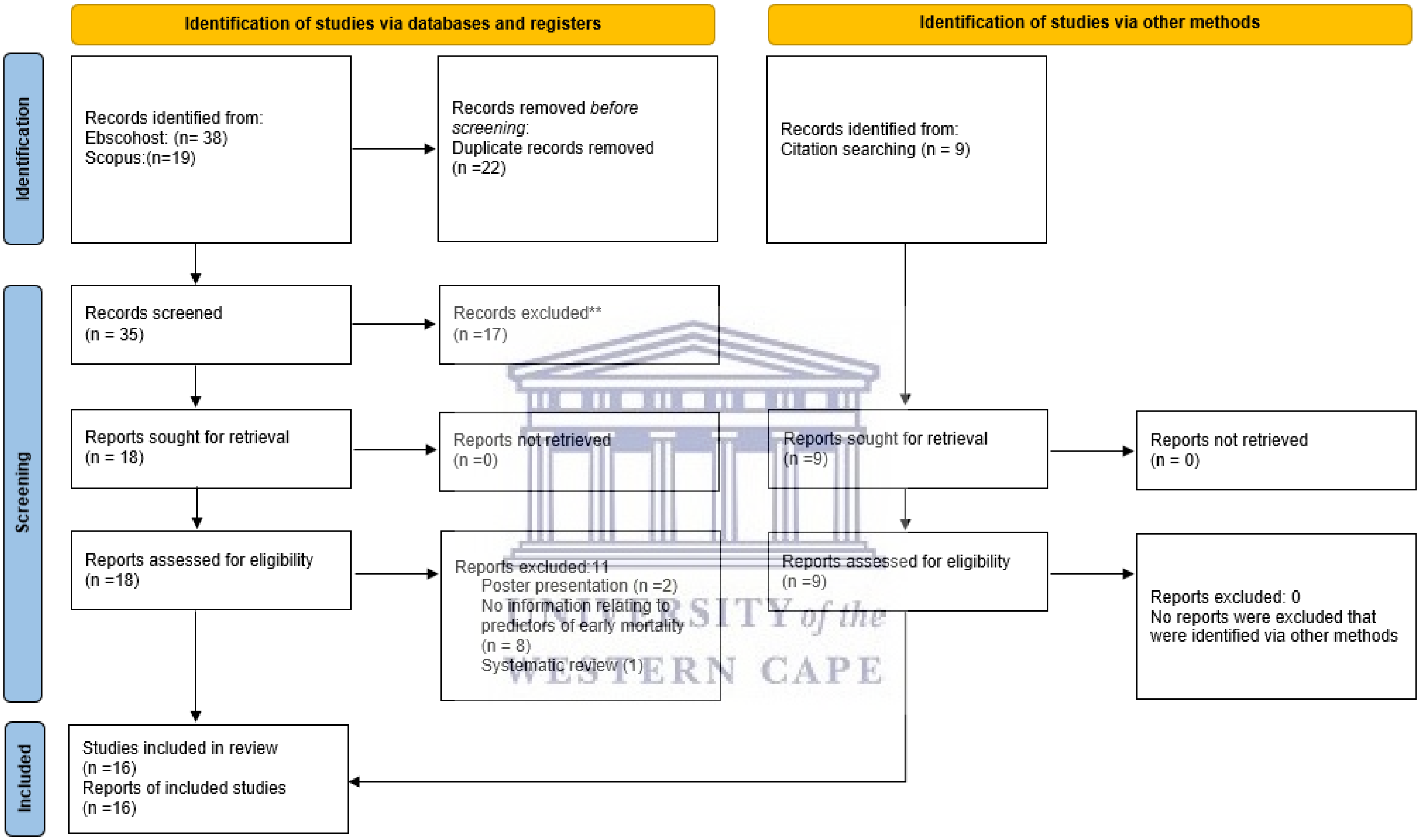


Figure 3. 1 PRISMA flow diagram

Table 3.1 Characteristics of included studies identifying independent predictors of early mortality.

Study information	Study type	Aim or purpose	Sample size	Factored-in confounding	Mechanism of injury	Mortality %	Independent predictors
(Alimohammadi et al., 2020) **Iran**	Retrospective study design *Level III evidence*	To evaluate the predictors of in-hospital and six-month mortality in patients who sustained acute traumatic quadriplegia.	*n* = 87 injuries M = 48 F = 39	Yes	1. Road traffic crashes (67.8%) 2. Fall (11%) 3. Violence (9.2%) 4. Struck by object (5.7%) 5. Sport (4.6)	In-hospital: 21.86% Six-month: 11.76%	**Predictors (in-hospital mortality)** • Level of injury (non-modifiable) • Presence of respiratory failure (modifiable) **Predictors (six-month mortality)** • Level of injury (non-modifiable)
(Inglis et al., 2020) **Canada**	Retrospective study design *Level III evidence*	To outline risk factors associated with in-hospital mortality in elderly (≥ 65 years) surgical and non-surgical patients following tSCI	*n* = 1340 injuries M = 957 F= 383	Yes	1. Falls (77.4%) 2. Transport (16.2%) 3. Sports (2.4%) 4. Other (4%)	Overall: 16% Surgical group: 10% Non-surgical group: 27%	**Predictors** • Age (non-modifiable) • Concomitant comorbidities (non-modifiable) • Neurological severity (AIS) (non-modifiable) • Ventilation status (modifiable)

		and to determine those unlikely to have a favourable outcome.					
(Banaszek et al., 2020) Canada	Retrospective study design *Level III evidence*	To determine the effect of frailty on patient outcome after traumatic spinal cord injury (tSCI).	*n* = 634 injuries M = 488 F = 146	Yes	1. Falls (46.5%) 2. Transport (25.2%) 3. Sports (21.1%) Other (7.1%	Not stated	**Predictors** • Age (non-modifiable) • Motor score on admission (non-modifiable)
(Bokhari et al., 2019) Australia	Retrospective study design *Level III evidence*	To identify the demographics and complications in elderly cervical spine injuries and predictive factors for surgery,	*n = 223 injuries M=113 F=112*	Yes	1. Falls 2. Motor vehicle accident 3. Fall from height >2m 4. Fall from height <2m 5. Sports 6. Pedestrian	In-hospital (Sub-groups) Incomplete cord injury: 32% Complete cord injury: 100% Non-operative: 12.9% Operative :18.5%	**Predictors** • Neurological deficit • Comorbidities (non-modifiable) • Presence of other injuries (non-modifiable)

		complications and mortality.					
(Shibahashi et al., 2019) **Japan**	Retrospective study design *Level III evidence*	To determine the epidemiology, identify predictors of early mortality, and develop predictive models for traumatic spinal cord injury.	*n =8069* *M = 6294* *F= 1775*	Yes	2004 - 2007 1. Road traffic accidents 2. Fall from a height 3. Fall at ground level 2008 onwards 1. Fall at ground level	In-hospital: 5.2%	**Predictors** • Increased age (non-modifiable) • Gender: Male (non-modifiable) • Low GCS on admission (non-modifiable) • Hypotension on arrival (modifiable) • Bradycardia on arrival (modifiable) • Severe head injury (non-modifiable) • Higher ISS (non-modifiable) • Complete spinal cord syndrome (non-modifiable)
(Alsaleh et al., 2017) **Saudi Arabia**	Retrospective study design *Level III evidence*	To assess the in-hospital mortality rate in adult	*n = 62 injuries* *M= 49* *F= 13*	Yes	4. Motor vehicle accidents 5. Fall	In-hospital: 17.7%	**Predictors** • Advanced age (non-modifiable)

		patients suffering acute traumatic complete quadriplegia and determine the possible predictors of mortality in these patients.		6. Sports/gunshots		• Comorbidities (non-modifiable)
(Daneshvar et al., 2013) Canada	Retrospective study design *Level III evidence*	To determine the mortality rate of elderly patients with SCIs related to C-spine fractures and identify factors that contribute to a higher risk for negative outcomes.	No (Subgroup and multivariate analysis not used due to small sample size)	Not stated	In-hospital: 38%	**Predictors** • Level of injury (C4) (non-modifiable) • Severity of injury (complete) (non-modifiable)

(Tee et al., 2013) Australia	Retrospective Study design *Level III evidence*	To identify early independent mortality predictors after spine trauma.	*N = 215* *M = 150* *F= 65*	Yes	1. Fall (43.3%) 2. MVA (50.2%) 3. Non- motor vehicle accident (0.4%) 4. Other (4.1%)	In-hospital: 48%	**Predictors** • ISS (non-modifiable) • Abnormal coagulation profile (modifiable) • Age 65 years and older (non-modifiable) • Hypotension (modifiable) • Tachycardia (modifiable) • Hypoxia (modifiable) • Multiple comorbidities (non-modifiable)
(Varma et al., 2010) USA	Retrospective study design *Level III evidence*	To identify predictors of early mortality following traumatic spinal cord injury (tSCI).	*n = 1995* injuries M= 1493 F=501	Yes	Not stated	In-hospital: 13%	**Predictors** • Age (non-modifiable) • Gender: Male (non-modifiable) • Severe systematic injuries ISS (>15) (non-modifiable) • Concomitant TBI (non-modifiable) • One or more comorbidities (non-modifiable)

							• Poor neurological status (non-modifiable) • Level one trauma centre (modifiable)
(Claridge et al., 2006) **USA**	Retrospective study design *Level III evidence*	This study was undertaken to analyse hospital mortality and disposition of patients with SCI with a specific focus on evaluating the effect of payor source on discharge. to a RF.	*n = 492 injuries* *M= 417* *F=75*	Yes	1. Blunt force trauma (76.7) (Remaining causes of injuries were not specified)	In-hospital: 7.7%	**Predictors** • Level of the injury: Cervical spine (non-modifiable) • Number of blood transfusions received (modifiable)
(Neumann et al., 2009) **Brazil**	Retrospective study design *Level III evidence*	To identify predictors of death in traumatic cervical spinal cord injury	*n* = 84 injuries M = 71 F = 13	Yes	1. Car crash (39%) 2. Falls (37.8%) 3. Penetrating wound/ hit	In-hospital: 26.2%	**Predictors** • GCS score < 9 (non-modifiable) • Mechanical ventilation (modifiable)

		(tSCI) in Brazil.			with object (21.95%) 4. Crushing (1.22%)		• Vasopressor use (modifiable)
(Furlan & Fehlings, 2009) Canada	Retrospective study design *Level III evidence*	To determine whether age at time of injury affects mortality, motor sensory recovery, and functional recovery in chronic stage after traumatic spinal cord injury.	*n = 499* injuries *M* *F*	Yes	1. Motor vehicle accident 2. Fall Other	**6 Weeks** Older: 25% Younger: 2% **6 months** Older: 36.4% Younger:2.2% **1Year** Older: 38.6% Younger: 3.1%	**Predictors** • Age (non-modifiable) • Severity of SCI (non-modifiable)
(Michael et al., 1999) USA	Retrospective study design *Level III evidence*	To identify and quantify trends in mortality and causes of death among persons with spinal cord injury.	*N=2823* *9* *M=2290* *2* *F=* *5337*	Yes	1. Motor vehicle accident (43.3%) 2. Violence (18.8%) 3. Falls (18.5%)	Not stated	**Predictors** • Age (non-modifiable) • Gender (non-modifiable) • Injury level (non-modifiable) • Frankel Grade (non-modifiable)

					4. Sporting injuries (11.3%) 5. Other causes (8.1%)		• Ventilator status (modifiable)
(Claxton et al., 1998) **Canada**	Retrospective study design *Level III evidence*	To identify predictors of death and mechanical ventilation in patients with traumatic cervical spinal cord injury.	*n* = 72 injuries M = 62 F =10	Yes	6. Falls/jumps (44%) 7. Motor vehicle accidents (36%) 8. Sports injuries (14%) 9. Hit by an object (4%)	In-hospital: 21% (Thirteen deaths in the ICU and two deaths outside the ICU)	**Predictors (First three months)** • Age (non-modifiable) • Neurological level (non-modifiable) • GCS (non-modifiable)
(Daverat et al., 1989) **France**	Prospective study design *Level II evidence*	The objective was to estimate mortality rates in SCI patients and to determine initial predictors of survival	*N=157* *M=129* *F=28*	Yes	Not stated	**3 months: 20%** Among tetraplegic: 29% Among paraplegic: 11%	**Predictors (First three months)** • Age (non-modifiable) • Initial conscious level (non-modifiable) • Respiratory assistance (modifiable)

(Griffin et al., 1985) USA	Retrospective study design *Level III evidence*	Mortality, survival and prevalence of traumatic spinal cord injury in Olmsted County, Minnesota, 1935-1981	*n* =154 M=111 F=43	Yes	Not stated	**Prior to hospitalised:**38 %	**Male** • Single marital status (modifiable) • Concomitant head trauma (non-modifiable) **Females** • Mechanism of injury (non -modifiable)

GCS: Glasgow coma scale; AIS:ASIA impairment scale; ISS: injury severity score; TBI: Traumatic brain injury; ICU: Intensive Care Unit; n/a: Not applicable; Level III evidence: Cohort or case control studies

3.4 DISCUSSION

As seen in Table 3.1, very few of the included studies found system-related factors as independent predictors of mortality. This clearly shows the lack of published literature and the need to understand the influence of process and structural measures of care on early mortality. Alternatively, it could be that the process issues were not relevant in the context of the studies. The main factors associated with mortality were predominately related to:

- demographics *(age and gender)*
- injury characteristics *(injury severity score, level of injury, severity of injury, level of consciousness, fragility, physiological parameters, mechanism of injury)*
- process measures *(surgical intervention, admission to level one trauma centre, pharmacological intervention)*
- secondary complications *(infections, pneumonia/respiratory failure)*; and
- multiple pre-existing comorbidities.

3.4.1 Personal factors

3.4.1.1 Age

Nine (Alsaleh et al., 2017; Banaszek et al., 2020; Claxton et al., 1998; Daverat et al., 1989; Furlan & Fehlings, 2009; Inglis et al., 2020; Shibahashi et al., 2019; Tee et al., 2013; Varma et al., 2010) of the sixteen studies reported on age. In the study by Tee et al. (2013), age was seen as an independent predictor relating to mortality, which was more so for those patients who were older than 65 years of age and who presented with a higher injury severity scale (ISS) (Tee et al., 2013) which quantifies the combined effects injuries sustained by the patients. Fifty-eight per cent of participants who were demised fell within the age category of 65 years and older (Tee et al., 2013). The findings mentioned above by Tee et al. (2013) were similar to those by Alsaleh et al. (2017), who found that patients who did not survive were much older than those patients who survived (median age = 73 years). However, in Asaleh's study, no significant difference with respect to age was noticed for those who were characterised as early and late deaths (Alsaleh et al., 2017). Shibahashi et al. (2019), also reported the median age of fatalities to be 73 years, with a range from 62 to 81years. The study by Furlan and Fehlings (2009) found similar findings at 6 weeks (25%), 6 months (36.4%) and one year post-injury (38.6%) for persons of advanced age (Range: 65-92), with the majority of deaths occurring within the first six weeks following injury. The fact that patients who fell within the elderly age group were at increased risk of early mortality was further corroborated by Inglis et al. (2020). He found the highest rate of mortality in the age category of 77-85 years for those who underwent surgery compared to the age category of 80-90 years for those patients who did not receive any form of surgical intervention. Patients in the non-surgical group who were 80 years and older were at a higher probability (14 times) of mortality than when compared to patients within the age category of 65-75 years (Inglis et al., 2020). While the odds of mortality in the surgical group of patients, who were 77 years and 50 days post-surgery, were six times higher than those patients in the age category of 65-75 years (Inglis et al., 2020). Studies by Claxton et al. (1998) and Varma et al. (2010) conversely found that increased risk of mortality started at a much younger age. This could be explained as being the result of increasing numbers of comorbidities in the younger population and the fact that these individuals usually present with severe concurrent systemic injuries (Varma et al., 2010). Furthermore, Claxton et al. (1998) found that patients who were 40 years and older were predicted to have a higher degree of mortality (odds ratio: 1.22), while Varma et al. (2010) noted that persons 20 years and older experienced an increased odds of reduced survival, compared to those persons who were 20 years and younger, where age was not associated with a reduced chance of survival. Lastly, Banaszek et al. (2020) noted that age at onset of injury was only associated with an increased odds of mortality, however, it was not actually predictive of it. In addition, Daverat et al. (1989) proved that age was predictive of survival of patients who sustained tSCI one year after injury. From the above-mentioned findings, patients who are of advanced age are at a higher risk of mortality, and therefore in-hospital care may need to be intensified to improve survival of patients who fall with this grouping. Furthermore, age should be factored in when making decisions about patient prognosis especially regarding survival.

3.4.1.2 Gender

Two studies (Alimohammadi et al., 2020; Varma et al., 2010) reported on gender. In the study by Alimohammadi et al. (2020), no difference in mortality was noted between male and female patients. However, in the study by Varma et al. (2010), the odds of early mortality for males were much higher than when compared to their female counterparts. But this may be due to confounding as males had higher ISS scores (>15). Although very few studies reported on gender and its association with mortality, several studies indicated that males formed a larger percentage of patients who did not survive following injury (Alsaleh et al., 2017; Claridge et al., 2006; Griffin et al., 1985; Inglis et al., 2020;

Neumann et al., 2009; Tee et al., 2013). This finding may be due to the severity of injuries males sustained concerning the mechanism of injury, as it has been proven that males tend to engage in riskier behaviour (Tamás et al., 2019). Although this is the case, there is inconclusive evidence from the above studies that gender differences in mortality exist following tSCI.

3.4.2 Injury factors

3.4.2.1 Injury severity (Injury Severity Score)

Eight (Alsaleh et al., 2017; Bokhari et al., 2019; Claridge et al., 2006; Inglis et al., 2020; Neumann et al., 2009; Shibahashi et al., 2019; Tee et al., 2013; Varma et al., 2010) reported on injury severity. A large proportion of studies found ISS scores greater than or equal to 15 to be highly predictive of early mortality in persons who sustained tSCI (Bokhari et al., 2019; Claridge et al., 2006; Inglis et al., 2020; Neumann et al., 2009; Varma et al., 2010). ISS, coupled with other independent predictors such as age, further increases a patient's risk (Bokhari et al., 2019; Tee et al., 2013). Contrary to the aforementioned studies, differences in ISS scores were not noted between those who survived and those who did not survive in the study by Alsaleh et al. (2017), as ISS scores were similar in both groups (median 25; range 16-75). It is evident from the findings above that a patient who presents with polytrauma, or an increased number of associated injuries, is at a greater risk of early mortality, which impacts short-term survival (Reyes et al., 2022). Furthermore, as stated by Tee et al. (2013), the presence of severe polytrauma is considered non-modifiable as these are injury characteristics that have already taken place and are unable to change. Timely access to radiological services (Consortium for

Spinal Cord, 2008) and the standardised use of the ISS can benefit in identifying high-risk cases. Furthermore, based on the findings related to polytrauma and its association with early mortality, it may be necessary to assess closely (Consortium for Spinal Cord, 2008) and monitor these patients to ensure associated injuries are managed appropriately and timeously to improve patient survival.

3.4.2.2 Level of injury

Besides the relevance of trauma scores, the injury level seemed to contribute to early mortality, especially with patients who sustained high-level cervical lesions. In this regard, seven (Alimohammadi et al., 2020; Alsaleh et al., 2017; Bokhari et al., 2019; Claridge et al., 2006; Claxton et al., 1998; Daneshvar et al., 2013; Tee et al., 2013) of the included studies reported on spinal injury levels. Patients in the included studies, who did not survive, presented with high or low cervical spine lesions (Alimohammadi et al., 2020; Alsaleh et al., 2017; Bokhari et al., 2019; Claridge et al., 2006; Claxton et al., 1998; Daneshvar et al., 2013; Tee et al., 2013). However, Alimohammadi et al. (2020), Claridge et al. (2006), and Bokhari et al. (2019) did not specify the exact spinal injury level, which was most common among those patients who had demised following cervical spinal trauma. Contrary to the results of the above studies, Daverat et al. (1989) found that the level of injury was not predictive of early mortality. The authors of the study explained this finding as a result of selection bias whereby younger patients who present with complete tetraplegia are more likely to be admitted to hospital and survive compared to older patients who usually die before reaching the hospital setting (Daverat et al., 1989). From the studies mentioned above, it can be clearly seen that patients who present with cervical spine injuries were at an increased risk of reduced survival during the acute period following SCI, compared to patients who have much lower spinal cord lesions. Once again, timely access to radiological investigations (Consortium for Spinal Cord, 2008) is key in determining the exact level at which the patient sustained their injury so that appropriate management can be commenced.

3.4.2.3 Severity of spinal injury (Complete or incomplete)

Two studies (Daneshvar et al., 2013; Neumann et al., 2009) reported on the severity of the spinal lesion. These studies found that patients with a complete spinal lesion classified as either an ASIA A or Frankel A increased a patient's risk of mortality than when compared to patients who were classified as an ASIA B, C or D. However, the severity of the lesion was not found to be an independent predictor of mortality in the study by Neumann et al. (2009). The studies assessing the severity of injury found that patients who presented with complete spinal lesions were at a higher risk of early mortality than patients with incomplete spinal lesions. As noted in the literature, there is conflicting evidence with respect to when exactly the ASIA impairment scale should be administered (Kirshblum et al., 2021). However, irrespective of the timing of assessment, it remains a vital tool for functional prognostication purposes and stratifying patients with high or low risk of mortality. Thus, emphasising the need for a more intensified care package for these patients following injury.

3.4.2.4 Level of consciousness (Glasgow Coma Scale)

Eight studies (Claridge et al., 2006; Claxton et al., 1998; Daverat et al., 1989; Griffin et al., 1985; Neumann et al., 2009; Shibahashi et al., 2019; Tee et al., 2013; Varma et al.,

2010) reported on decreased consciousness levels. GCS scores of ≤ 13 on admission to care were found to decrease the likelihood of survival (Claridge et al., 2006; Claxton et al., 1998; Daverat et al., 1989; Neumann et al., 2009; Shibahashi et al., 2019). However, it is important to note that low GCS on admission could result from respiratory dysfunction resulting in hypoxia or TBI brought upon by the mechanism of injury (Claxton et al., 1998). Although not part of the final predictive model in the study conducted by Tee et al. (2013), the authors found that the presence of severe TBI was associated with a higher risk of mortality. However, the existence of TBI was predictive of early mortality in the studies by Griffin et al. (1985) and Varma et al. (2010). In the study by Varma et al. (2010), 15% of patients who demised presented with TBI. However, Griffin et al. (1985) only found TBI to be predictive of early mortality in males as opposed to females. Hence, low GCS scores, which could be the result of other factors, are seen as an important predictor to consider when determining short-term survival of patients. From the above findings, one can deduce that poorer consciousness levels on admission, which may be due to TBI or respiratory dysfunction, reduces a patient who sustained an tSCI's probability of short-term survival.

3.4.2.5 Fragility

One study (Banaszek et al., 2020) reported on patient fragility. According to Fried et al. (2004), frailty is defined as *"a state of high vulnerability for adverse health outcomes, including disability, dependency, falls need for long term care and mortality".* In the study by Banaszek et al. (2020), patient fragility was found to be an independent predictor of mortality in patients < 60 years of age, while motor scores on admission were considered a predictor of mortality in persons within the age categories of < 60 years, 61-75 years and 76+ years. Furthermore, patients who fell within the frail grouping experienced an increased risk of developing secondary complications and had higher percentages of cervical injuries (i.e., high and low) compared to the non-frail grouping, who had a higher probability of survival (Banaszek et al., 2020). Besides the study by Banaszek et al. (2020), no further studies assessed the impact of fragility on persons who sustained tSCI. Furthermore, the concept of fragility should not only be associated with the elderly population group but should also include patients who fall within your younger age groupings owing to the rise of comorbidities and disease in this population group.

3.4.2.6 Physiological parameters

Four (Alimohammadi et al., 2020; Claridge et al., 2006; Shibahashi et al., 2019; Tee et al., 2013) studies reported on physiological parameters. Tee et al. (2013) identified the following physiological parameters that were predictive of mortality: hemodynamic instability, abnormal coagulation and hypoxia. These physiological parameters were termed as being modifiable since medical management can alter their course (Tee et al., 2013). Similar findings relating to physiological variables were seen in the studies by Alimohammadi et al. (2020) and Shibahashi et al. (2019), who noted that patients who presented with bradycardia were at an increased odds of mortality (odds ratio: 4.22 and 1.4, respectively). Shibahashi et al. (2019) also found hypotension to increase the odds. Furthermore, the number of blood transfusions required during hospitalisation seemed to predict a patient's probability of early mortality (Claridge et al., 2006). However, this could be related to the fact that patients who present with higher ISS on admission could have a greater degree of blood loss requiring more blood transfusions, as polytrauma (increased ISS) has been identified as an independent predictor of mortality. Although not many studies assessed the impact of physiological parameters on early mortality, it remains an important factor which could assist in early risk stratification of patients at the point of care.

3.4.2.7 Mechanism of injury

Three studies (Alsaleh et al., 2017; Furlan & Fehlings, 2009; Griffin et al., 1985) studies reported on the mechanism of injury. According to the study by Alsaleh et al. (2017), the mechanism of injury was associated with early mortality as 8 of the 11 patients who demised sustained injuries due to fall, while the remaining two patients were injured due to transport-related aetiology. However, the mechanism of injury did not form part of the final predictive model (Alsaleh et al., 2017). The cause of injury was also not associated with mortality in the study by Furlan and Fehlings (2009) (HR: 0.78), hence not included in the final predictive model. On the other hand, Griffin et al. (1985) found pedestrian and bicyclist status at the time of injury to be predictive of early mortality in females, while the mechanism of injury was not predictive of early death in males even though 60% of injuries were related to transport aetiology. The impact of aetiology on early mortality was not consistently reported upon in each study; however, mechanisms of injury which increase the likelihood of polytrauma (e.g., transport and fall-related aetiology) may need to be closely monitored as they usually present with higher injury severity scores which has been documented as an independent predictor of mortality.

3.4.3 Process factors

3.4.3.1 Surgical intervention

Three (Alimohammadi et al., 2020; Bokhari et al., 2019; Inglis et al., 2020) of the included studies reported on surgical management. According to the study by Alimohammadi et al. (2020), patients who did not receive early surgery (i.e.,> 48hrs) or no surgery were at 4.19 and 6.12 higher risk of early mortality, compared to patients who received early (i.e.,< 48hrs) surgical intervention. This means those patients who received surgical intervention earlier rather than later had a greater chance of short-term survival as their risk of mortality was reduced. In the study by Inglis et al. (2020), 53%, 83% and 91% of patients within the non-surgical group died within one week, one month and 2 months following injury. While 16%, 60%, 76% and 97% of patients in the surgical group died within one week, one month, two months and six months following surgery (Inglis et al., 2020). Majority of patients in the non-surgical group died within 20 days following injury compared to patients in the surgical group, where the largest proportion of patients died within 50 days post-injury (Inglis et al., 2020). Predictors of in-hospital mortality of patients in the surgical group were age, comorbidities, neurological injury severity (AIS) and ventilation status, while predictors of mortality for the non-surgical group were only age and neurological injury severity (AIS) (Inglis et al., 2020). In the study Inglis et al. (2020), mortality was also associated with admission to an ICU, with the total length of ICU stays being significantly longer in the group of patients who demised. However, the study by Bokhari et al. (2019) stated that no difference existed with respect to in-hospital mortality when comparing those patients who underwent surgery and those who did not. However, a slightly higher percentage of deaths was noted for those who fell within the operative group (18.5%)

than when compared to the non-operative grouping (12.9%). The findings from the above-mentioned studies did not confirm whether access to surgery or the lack thereof can be considered an independent predictor of mortality. Nevertheless, what can be noted from two of the three studies addressing surgical intervention is that patients who did not receive surgical management were at a higher probability of early mortality than those who did. There is a possibility that the severity of the injury (i.e., complete vs incomplete) or ISS impact on the decisions made by clinicians as to whether certain patients receive surgical interventions early or not (Ter Wengel et al., 2018). Further research regarding its influence on mortality in tSCI is needed.

3.4.3.2 Admission to level one trauma centre

One study (Varma et al., 2010) reported on admission to level one trauma centres. As stated in Chapter 2, timely access to level one trauma facilities is essential to patient prognosis and survival. Level one trauma centres are tertiary healthcare facilities that offer specialised trauma services to treat various medical conditions and injuries. A rather strange finding related to process measure outcomes was that persons with tSCI who were admitted to level 1 trauma centres had increased odds of early mortality (Varma et al., 2010). This result was, however, explained under the premise that patients who presented with higher ISS scores were managed at the level 1 trauma centre (Varma et al., 2010). This result by Varma et al. (2010) could be due to the fact that injury severity, as documented by the ISS, was not controlled for during analysis. However, the lack of timely access to level one trauma centres (i.e., patients who received intermediate hospitalisation) may be seen as a possible risk factor for early mortality following spinal injury. However, evidence regarding this candidate exposure remains inconclusive.

3.4.3.3 Pharmacological intervention

Three studies (Alimohammadi et al., 2020; Furlan & Fehlings, 2009; Neumann et al., 2009) reported on pharmacological interventions. Patients who did not receive methylprednisolone were 15 times more likely to die in the hospital compared to patients who received MP on admission (Alimohammadi et al., 2020). The findings by Alimohammadi et al. (2020) were contrary to those by Furlan and Fehlings (2009), who found that patients who received standard or alternative strategies of MP were at almost three times higher risk of dying (HR: 2.62). The study by Neumann et al. (2009) found the use of vasopressors as an independent predictor of mortality as 57.1% of patients who demised were administered vasopressors. The mortality rate for this group of patients increased as GCS scores decreased for those receiving vasopressors (Neumann et al., 2009). Based on the above, there is inconclusive evidence to suggest that vasopressor use impacts on early mortality in the tSCI population, however, it has been linked to poorer outcomes in patients who have sustained traumatic injuries (Hylands et al., 2017).

3.4.3.4 Secondary medical complications

Ten studies (Alimohammadi et al., 2020; Banaszek et al., 2020; Bokhari et al., 2019; Claridge et al., 2006; Claxton et al., 1998; Daneshvar et al., 2013; Daverat et al., 1989; Inglis et al., 2020; Neumann et al., 2009; Tee et al., 2013) reported on complications found in patients who died prematurely. In the study by Tee et al. (2013), the leading secondary complications in the survivor and non-survivor groupings were infections (survivor group:27.7% ; non-survivor group: 25.5%) and pneumonia (survivor group: 11.6%; non-survivor group: 21.6%). The occurrence of pneumonia was also relatively high in the study by Bokhari et al. (2019), who found that pneumonia and respiratory failure were the most prevalent complications in the non-operative (12.3%; 12.9%) and operative (43%; 27.8%) groupings. Twenty-eight (87.5%) of the 32 patients who died presented with respiratory failure, with all ten patients in the operative group dying solely from respiratory failure (Bokhari et al., 2019). However, the study by Bokhari et al. (2019) did not link the prevalence of these secondary medical complications to the level of injury. The aforementioned findings were similar to those of Daneshvar et al. (2013), where 57.1% (*n*=8) of patients who demised presented with respiratory failure. Pneumonia was also found to be the most prevalent complication in the studies by Neumann et al. (2009) and Banaszek et al. (2020), where 42.9% (9/22) and 51.3% of patients presented with pneumonia in the mortality (Neumann et al., 2009) and frail (Banaszek et al., 2020) groupings. In Claridge et al. (2006), 54.1% of patients who demised with ventilator-acquired pneumonia, which was found to be associated with mortality. While Claxton et al. (1998), reported that 60% (9/15) of patients who did not survive died as a result of respiratory complications. In support of the above Alimohammadi et al. (2020) found that patients who presented with respiratory failure were at 3.81 times higher odds of mortality, while Daverat et al. (1989) and Inglis et al. (2020) found that patients who required respiratory assistance were at a reduced probability of survival. Furthermore, patients who underwent surgery were more likely to develop secondary medical complications such as pneumonia, respiratory failure, cardiac arrhythmia and deep vein thrombosis

(Bokhari et al., 2019). As reported in the studies above, pneumonia and respiratory failure were the most common secondary complications to have occurred in patients who did not survive. Furthermore, pneumonia may also be linked to those cases where patients present with respiratory failure and may require assistance via mechanical ventilation to breathe. According to the evidence-based recommendations outlined in Chapter 2 Table 1.2 "*SCI patients are at a significant risk of cardiovascular and respiratory problems and management should be proactively anticipate these potential complications (Fehlings et al., 2011)*." These preventative measures involve removing copious amounts of secretions using physiotherapy or suctioning (Fehlings et al., 2011). While the medical management of pneumonia or VAP entails the prescription of gram specific antibiotics (Torres et al., 2018). Therefore, early referral for physiotherapy and appropriate use of antibiotics are essential in the prevention and management of pneumonia in this high-risk population.

3.4.4.5 Pre-existing comorbidities

Six studies (Alimohammadi et al., 2020; Alsaleh et al., 2017; Bokhari et al., 2019; Inglis et al., 2020; Tee et al., 2013; Varma et al., 2010) reported on the comorbidities of patients. In the study by Tee et al. (2013), independent irreversible predictors of mortality were seen as those patients who presented with multiple comorbidities. A large proportion of patients who did not survive (63.1%) had two or more comorbidities compared to those who did survive (27.7%) (Tee et al., 2013). There was a similar trend in the study by Alimohammadi et al. (2020), who found that each unit increase in the Charlson comorbidity index (CCI) score also increased the patient's probability of mortality by 5.43

times, while Inglis et al. (2020) proved that CCI scores between 1.4 and 2 increased a patients probability of in-hospital mortality. These findings are further supported by a prior study conducted by Alsaleh et al. (2017), who also identified pre-injury comorbidities as a predictor of reduced survival. In the study by Varma et al. (2010), 90 (36%), 50 (20%) and 41 (16%) of persons who demised out of a total of 251, had one, two and three or more comorbidities, respectively. The above studies did not refer to the exact comorbidities that should be screened, merely the number of comorbidities present. As the number of comorbidities increases, the risk of mortality does so too. Some studies used the CCI, which assesses the presence of the following: history of myocardial infarction; chronic heart failure; peripheral vascular disease; history of transient ischemic attack (TIA)/cerebrovascular accident (CVA); dementia, chronic obstructive pulmonary disorder; connective tissue disease; peptic ulcer disease; liver disease diabetes mellitus; hemiplegia and moderate to severe chronic kidney disease. Based on the above, the literature clearly shows that the number of pre-existing comorbidities a patient presents with does play a role in determining short-term survival of persons who sustained a tSCI. However, a need exists to identify specific comorbidities which are linked to mortality.

3.5 Conclusion

Several independent predictors relating to early mortality exist for persons who have sustained a tSCI. It is clear from Table 3.1 that most of the studies have been conducted in developed countries. The high prevalence rates with respect to Canada and the USA may be due to the preventative measures that have been put in place to mitigate some of the predictors of early mortality. Therefore, to identify patients who may be at a reduced probability of short-term survival, attention may need to be given to the following independent predictor variables, which were documented in the included studies: Demographical factors *(Age = ≥ 65 years, Gender = male)*; injury factors *(injury severity [ISS ≥ 15])*; level of spinal injury *[cervical spine high C1-C4 / low C5-C8]*; severity of spinal injury *[complete]*; level of consciousness *[GCS < 9]*; fragility *[classified as being frail]*; physiological parameters *[hemodynamic instability, hypoxia, bradycardia and abnormal coagulation]*; mechanism of injury *[falls; transport-related aetiology]*; process measures *(surgical intervention [no surgery])*; pharmacological interventions *[use of vasopressors and methylprednisone]*; secondary complications *(pneumonia/ Respiratory failure)I;* and pre-existing comorbidities *(multiple pre-exiting comorbidities).*

In addition, these early mortality predictors provide valuable information on how current healthcare processes in managing persons with tSCI can be improved to increase the probability of patient survival, especially in instances where predictors are modifiable. Therefore, the findings of this chapter have been used to inform the selection of candidate factors, which are routinely evaluated in the public healthcare setting, for the empirical longitudinal, observational study.

CHAPTER FOUR

METHODOLOGY

4.1 INTRODUCTION

This chapter details the methodology that was applied to address the study objectives. The researcher discusses in detail the research design, which in this case, was a prospective in-hospital-based design. In addition, the researcher describes the research setting, which included the Cape Metropolitan area and the tertiary healthcare facility, Groote Schuur Hospital, where data collection had occurred. Furthermore, the population and sampling technique will be discussed as well as the data collection procedures and tools used to address the main aim of this study. In relation to the data collection procedure, findings from the rapid review (i.e., Chapter 3) informed the data collection on exposure variables related to early mortality. Additionally, the data analysis process will be explained in detail. Lastly, the ethical principles used in this study will be described.

4.2 STUDY DESIGN

The study employed a quantitative approach and the design was longitudinal and prospective in nature (Hammoudeh et al., 2018). A prospective study design entails following up with participants for a pre-determined period to assess whether they develop the outcome in question (Hammoudeh et al., 2018; Ranganathan & Aggarwal, 2018). In this specific study, participants who sustained a tSCI were followed up from the day of onset of injury to one-year post-injury. Furthermore, the prospective longitudinal design allowed the researcher to collect data on numerous variables concerning each individual patient without influencing the outcomes in question. On the other hand, the quantitative approach entails analysing the set of numerical data captured in response to the study's objectives (Quick & Hall, 2015). This approach was chosen as it is the most appropriate to describe the incidence cohort in detail and explore the possible associations between variables and their impact on mortality and survival.

Since participants were recruited from only one healthcare facility, the design is considered hospital based as opposed to population based since all cases of persons with traumatic spinal cord injury (tSCI) within the Cape Metropolitan region were not included. However, a previous study has found that more than 80% of acute tSCI cases are managed at the included hospital, providing adequate coverage of the source population. Furthermore, this design was chosen to identify the potential predictors of mortality and survival, since patients were followed up prospectively for 18 months (14 April 2017- 31 December 2018). In addition, this design may present with a high loss to follow-up rate (Song & Chung, 2010).

The study employed a positivist research paradigm, verifying a hypothesis that has been set up *a priori* and noting any functional relationship between independent and dependent variables (Park et al., 2020). From the perspective of this study, a positivist paradigm will assist in determining whether any relationships may exist between exposures and outcomes relevant to this study. The overall hypothesis by the researcher was that predictors of mortality are multifactorial (i.e., personal, injury and process factors are at play) and cannot be attributed to one sole factor. Furthermore, this research paradigm is closely linked to the hypothetico-deductive model of science, which is seen as a diagnostic reasoning model in the context of medicine (Donner-Banzhoff, 2018). Any significant findings could thus be considered for implementation.

4.3 RESEARCH SETTING

The research study was conducted at one government-funded tertiary hospital situated in the Cape Metropolitan area / City of Cape Town. Approximately two-thirds of the inhabitants that reside within the Western Cape live within the Cape Metro Metropolitan area.

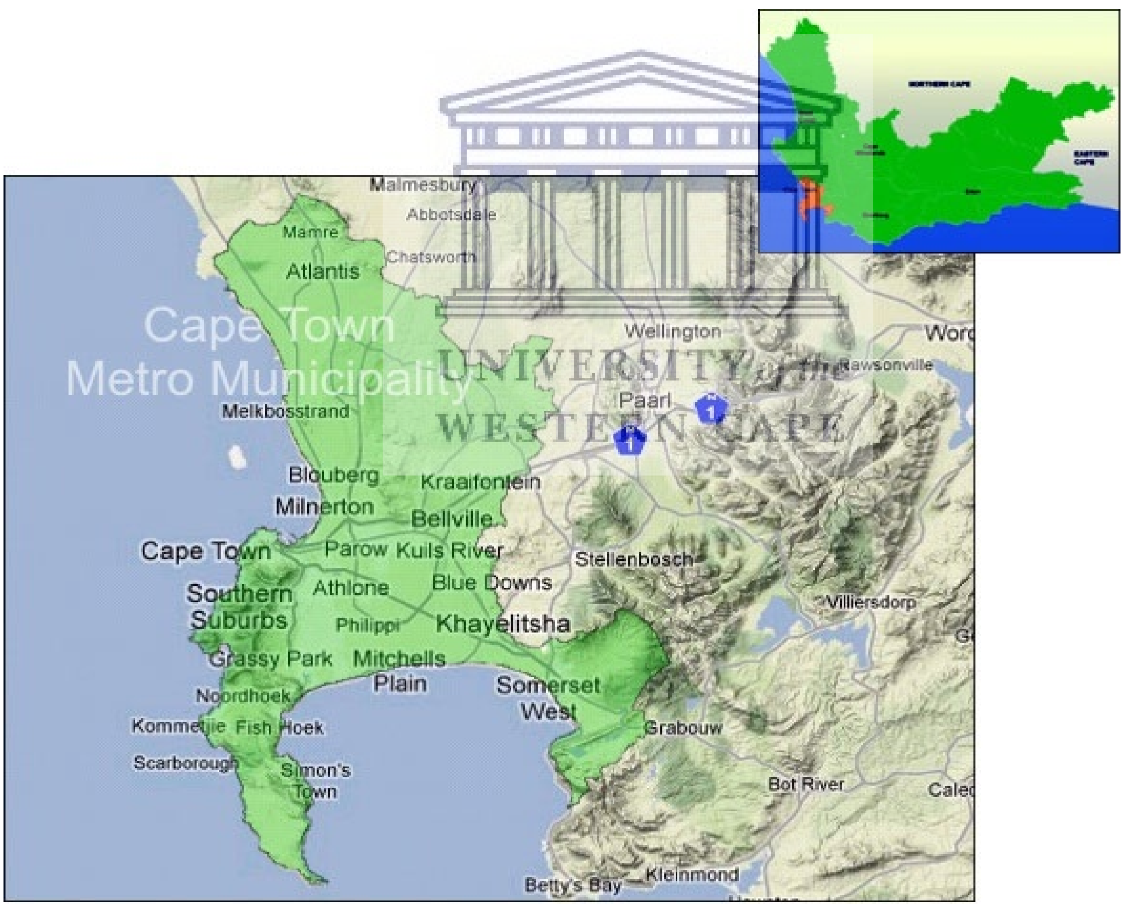


Figure 4. 1 Cape Town Metropolitan Municipality

People residing within the Cape Metropole come from a wide array of socio-economic backgrounds and live in a mix of urban and peri-urban environments. The City of Cape Town has a total population of 3 740 025 consisting of the following population groups: coloured (42.4%), black African (38.6%), White (15.7%), Indian/Asian (1.4%) and other (1.9%) (Statistics South Africa, 2011). According to Stats SA, the metros unemployment rate is at 23.9% (Statistics South Africa, 2011). The only level 1 government-funded tertiary trauma centres within the Cape Metropolitan area are Groote Schuur Hospital (GSH) and Tygerberg Hospital. Groote Schuur Hospital is the only government-funded hospital in the Western Cape that offers specialised acute care for patients who have sustained an acute tSCI. Patient care within the acute spinal care unit (ASCI) is provided in a multidisciplinary approach, which incorporates trained medical practitioners and allied health workers (i.e., physiotherapists, occupational therapists, dieticians and social workers). These practitioners and health workers are trained and experienced in managing patients who have sustained a tSCI from the acute phase till discharge. The ACSI unit was established in April 2003 and consists of only six beds in total. Four ICU beds are assigned to ventilated patients, while only two beds are available for non-ventilated patients (Sothmann et al., 2015). Once patients have been admitted to the ASCI unit after a spinal cord injury (SCI), the goal is to stabilise the patient from a physiological and mechanical perspective (Sothmann et al., 2015). However, time to surgery, which has been shown to improve patient outcomes, may only occur 10 days following the onset of the injury, while patients admitted to acute care can stay on average 37 days with a median of 24 days (Conradsson et al., 2019). Apart from a specialised ICU ward for persons with SCI, there is a dedicated general ward in which less severe cases are admitted, or patients who have been transferred from the ICU once their condition has improved. Patients were recruited exclusively from GSH as the facility treats approximately 75% of the total population of persons who sustain tSCIs within the Cape Metropolitan region (Joseph et al., 2015), with the remaining percentage accessing healthcare through private medical aid services.

4.4 STUDY POPULATION AND SAMPLING

Patients who sustained a tSCI between 14 April 2017 – 31 December 2018, and were admitted to GSH, were eligible for inclusion in this study. The researcher anticipated a similar number of participants to be recruited in this study as in the study conducted by Joseph et al. (2015), which had a total number of 150 participants.

4.4.1 Sampling type

A total population sampling technique, sometimes known as consecutive sampling technique, was employed whereby each consecutive person admitted to GSH with a tSCI, meeting the inclusion criteria, was included in the study. This type of sampling technique seeks to include the whole target population in question and was therefore considered the best form of non-probability sampling to use (Hulley, 2007). Furthermore, there is no degree of volunteerism or any other form of selection bias, as each participant meeting the inclusion criteria as noted above, was included (Hulley, 2007). Based on these advantages, this sampling strategy seemed to fit the study design best, as more confidence can be drawn from the findings on mortality and processes linked to it. However, this type of sampling technique has noticeable disadvantages as it may increase the degree of bias and likelihood of outliers (Etikan et al., 2016). Outliers were assessed by a sorting method and by determining interquartile ranges.

4.4.1.1 Inclusion criteria

In addition to the below-mentioned criteria, patients were only included if they were equal to and greater than seven days post-injury (Divanoglou & Levi, 2009; Joseph et al., 2015). Only patients surviving equal to and longer than seven days were eligible for inclusion in the study, since their injury would need to have been confirmed by a specialist physician.

All inclusion criteria were mutually inclusive and exclusive.

- A tSCI is defined as a sudden loss of voluntary muscle strength, sensation and autonomic functions below the level of injury, which will vary depending on the neurological level of injury and extent of impairment, but must include altered sacral sensation, in line with international standards for classification.
- The injury must result in persisting impairment (i.e., not just a concussion) after emergence from neurogenic shock, which generally occurs within the first 24-72 hours after injury.
- Abnormal imaging (see section 1.6), such as with MRI scan or multi-slice CT scan.
- Patients 18 years of age and older sustaining an acute injury (see section 1.6) within the surveillance year.
- Permanent residents of South Africa, which included South African citizens.

- Patients admitted to GSH to receive SCI care.
- Patients consenting to participate in the study i.e., informed written consent.

4.5 DATA COLLECTION

4.5.1 Data collection instruments

The following data collection tools were used:

- International Spinal Cord Society basic data set form (see Appendix 10);
- the International Standards of Neurological Classification (AIS) (see Appendix 11);
- the Spinal Cord Injury Conditions Scale (see Appendix 12) and
- data relating to key process measures (see Chapter 2, Table 2.2)

Figure 4.2 below outlines how the data collection instruments relate to the key domains within Krause's theoretical risk model for mortality and secondary medical conditions. The following sections will discuss each of these instruments in more detail.

4.5.2 Data collection tools and coverage in relation to the theoretical model

Krause's theoretical risk model	Study objectives	Data collection instruments
• Demographic and injury factors • Protectives and risk behaviours	Determine the profile of participants with tSCI according to the International Core Data Set.	International Spinal Cord Injury Dataset Form Spinal Cord Injury Secondary Conditions Scale (SCI-SCS)

• Secondary conditions / global health		International Standards for Neurological Classification: ASIA Impairment Scale
• Socio-environmental	To evaluate the processes of tSCI care within a specialised acute care setting.	International Spinal Cord Injury Dataset Form Rapid review
• Demographic and injury factors • Protectives and risk behaviours • Secondary conditions/global health	To conduct a rapid review to establish candidate processes (exposures) of care linked to acute management and survival.	Rapid review
• Protective and risk behaviours	To determine the prevalence of risk factors for mortality of persons with tSCI according to the theoretical risk model.	International Spinal Cord Injury Dataset Form Spinal Cord Injury Secondary Conditions Scale (SCI-SCS)
• Demographic and injury factors	To determine morbidity after tSCI.	International Standards for Neurological Classification: ASIA Impairment Scale

4.5.2.1 International Spinal Cord Injury Core Dataset Form

The international SCI Core Data Set form, developed by Michael DeVivo, Fin Biering-Sørensen, Susan Charlifue, Vanessa Noonan, Marcel Post, Thomas Stripling and Peter Wing form (Devivo et al., 2006), was designed to ensure data regarding tSCI can be collected in a standardised and uniform way so that it can be shared across countries. Furthermore, this structured approach and standardisation in reporting make the process easier to plan preventative measures and curb the occurrence of such injuries. The SCI core basic dataset form consists of the following variables related to persons who have sustained a tSCI (Biering-Sørensen & Noonan, 2016): birth date (age), injury date; gender; acute admission; final inpatient discharge; days hospitalised; injury aetiology; vertebral injury; associated injury; spinal surgery; ventilator assistance and neurological classification. Furthermore, this data set form highlights the following causes of tSCI: sports and leisure activities, assault, transport, falls and other traumatic causes (Biering-Sørensen et al., 2017). Assault was further categorised into gunshot and stabbing-related aetiology, while transport-related injuries were broken done into motor vehicle and pedestrian-related accidents. Each SCI data set form undergoes regular review by relevant committees, organisations and individuals involved in managing persons with tSCI. This review process is done by means of iterative consensus process which is based on the best available evidence thus contributing to its validity (Biering-Sørensen et al., 2017).The data with respect to the above-mentioned variables were primarily retrieved from the patient's medical folder on admission and discharge from the ASCI unit. This information was then populated on the data capturing sheet.

4.5.2.2 International Standards for Neurological Classification: ASIA Impairment Scale

The ASIA impairment Scale (AIS) is the most recent tool developed by the American Spinal Cord Injury Association to classify impairment levels of persons with an SCI (American Spinal Injury Association, 1984). The tool has a component that captures information about motor and sensory status, whereby patients are further characterised as having a complete or incomplete SCI (Biering-Sørensen & Noonan, 2016; Kirshblum et al., 2011). The reason for using this specific tool when collecting data was because it set out to determine the neurological level of injury and the severity of the SCI post-injury (Kirshblum et al., 2011), which is important in determining improvements in sensory and motor function post intervention. The AIS is seen as a reliable (Marino et al., 2008) and valid (Graves et al., 2006) instrument to be used within the spinal cord population group with an unweighted Kappa coefficient ranging from 0.68 - 0.78 ($P < 0.05$), which indicates a moderate agreement between raters (Furlan et al., 2011; Kirshblum et al., 2011; Maynard et al., 1997; Savic et al., 2007). Furthermore, several studies have assessed the convergent and content validity of the ASIA classification standards, and a systematic review reported that the instruments validity makes it suitable to use during various stages of the patient's pathway of care (Furlan et al., 2011). ASIA classification and scores (i.e., motor and sensory) were obtained from the participants' medical folder during the data collection process during admission and discharge from GSH.

4.5.2.3 Spinal Cord Injury Secondary Conditions Scale (SCI-SCS)

The Spinal Cord Injury Secondary Conditions Scale is a 16-item scale noting the most common reasons for rehospitalisation following an SCI (Kalpakjian et al., 2007). Although only used in cases where rehospitalisation has occurred, the complications contained in the SCI-SCS are still prevalent within the acute setting. Furthermore, reason for extracting data relating to the main secondary medical complications was because they directly impact the morbidity and mortality of persons who have sustained an SCI during the acute and post-acute phases (Joseph & Wikmar, 2016; Madasa et al., 2020). Only the following secondary complications as set out in the SCI-SCS were captured due to their prevalence within the acute setting: pressure sores(s) (yes/no); muscle spasms (spasticity) (yes/no); urinary tract infections (yes/no); autonomic dysreflexia (yes/no); postural hypotension (yes/no); circulatory problems (yes/no); respiratory problems (yes/no) and neuropathic pain (yes/no). The aforementioned secondary complications were noted as being present or not if the specific complication was documented in the participants' medical folder. With respect to scoring pain intensity, a numerical rating scale from 0-10 is the preferred method while a composite score can be determined by using the Neuropathic Pain Scale (Bryce et al., 2007). Following psychometric testing of the instrument, Cronbach's alpha exceeded 0.76, which indicating acceptable internal consistency with a test-retest reliability ranging from 0.569 to 0.805.(Kalpakjian et al., 2007; Kirshblum et al., 2011; Maynard et al., 1997) Lastly, only the presence (i.e., yes/no) of the secondary medical complication was captured during the participants period of hospitalisation.

4.5.2.4 Processes of care

A data extraction sheet, which was based on key measures of processes of care as was used when extracting data from the patients' medical folders. The processes of care that have been included were based on the recommendations of current acute care guidelines in managing persons with SCI (See Chapter 2 Table 2.2) and results from the rapid review (See Chapter 3). Obtaining data relating to these specific processes is important as they directly impact the morbidity and mortality following an acute SCI. Table 4.1 highlights the relevant processes and their outcomes that were captured and illustrates how Donabedian's model of care aligns and strengthens Krause's theoretical risk model, which neglects external input, such as health system structure and processes.

Table 4.1 Acute care processes

Acute care processes	Outcomes measurement	Domain of risk model
Spinal surgery	Decompressing/ stabilising spinal surgery (Yes/No) *If yes, time to first surgery*	Demographic/injury factors
Associated injuries evaluation	Screening for associated injuries (Yes/No) *Non-vertebral fractures requiring surgery; severe facial injuries affecting sense organs; major chest injury requiring chest-tube or mechanical ventilation; traumatic amputations of an arm or leg (or injuries severe enough to require surgical amputation); severe haemorrhaging or damage to any internal organ requiring surgery*	Demographic/injury factors
Specialised SCI care	Time (days) from accident scene to specialised SCI unit admission;	Socio-environmental

	number of intermediate hospitalisations	
Multidisciplinary team	Was the patient managed by a multidisciplinary team, i.e., defined as a medical doctor, rehabilitation personnel (occupational therapist; physiotherapist; speech therapist, dietician) and nurse (Yes/No)	Socio-environmental
Secondary complications prevention	Screening for secondary complications	Secondary conditions and global health Protective / risk factors
Length of acute care	Time (days) from first hospitalisation until the end of acute care	Socio-environmental
Rehabilitation	Referral to inpatient or outpatient rehabilitation	Socio-environmental

4.5.3 Data collection procedure

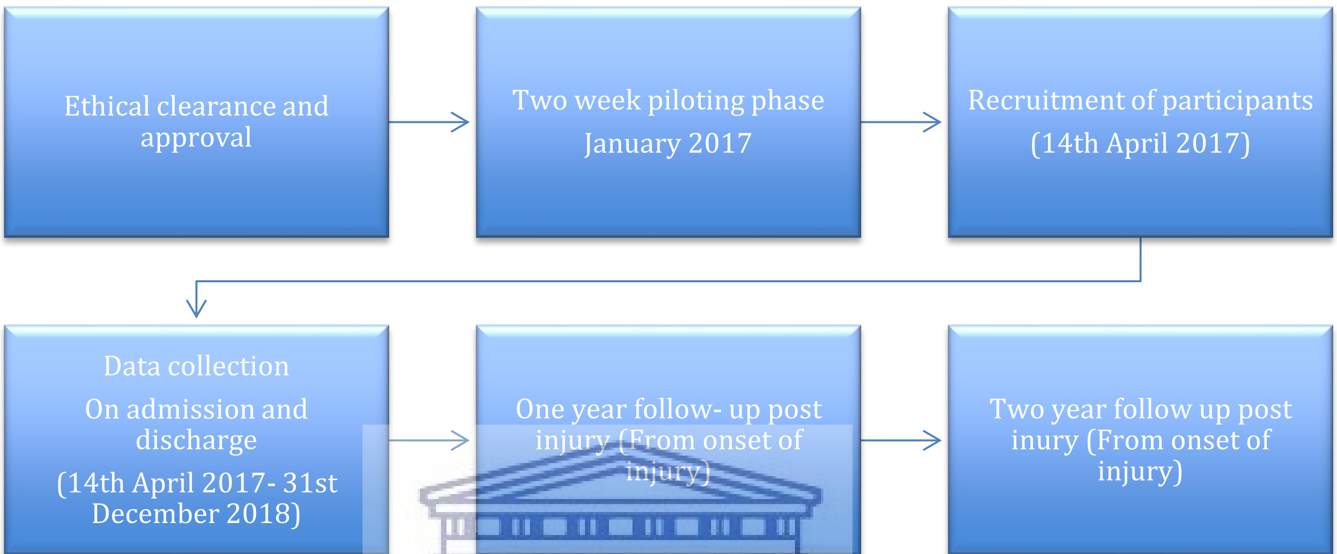


Figure 4.2 Brief overview of the data collection procedure

Data collection only commenced once the necessary ethical approval and permissions were obtained from the UWC Biomedical Research Ethics Committee (BMREC ethics number BM18/1/17) and GSH. Two spinal consultants linked to the ASCI unit were the contact persons at GSH. All newly injured persons with tSCI were included in a closed-ended cohort for 18 months. A two-week piloting period commenced in January 2017, with the actual data collection taking place between 14 April–31 December 2018. The cohort was classified as closed ended because participants were not replaced if they dropped out or were loss to follow up during data collection (Hammoudeh et al., 2018; Levin, 2006).

Prior to commencing data collection, a two-week piloting phase was performed to ensure that that self-developed data extraction sheet (See Appendix 14) extracted the necessary data the researcher needed.

The first phase of this study pertained to the incidence cohort, which included all patients who sustained tSCIs between the 14 April 2017 and 31 December 2018 (an 18-month period). This time frame was chosen because the highest risk of mortality in persons with tSCI occur within the first two years post-injury (Sabre et al., 2013). Participants were recruited by the researcher by checking the admission books twice a week within the spinal ICU, general ward SCI and trauma unit. Consultants within the ASCI unit were also approached to determine whether there were any patients in transit or who are yet to be admitted to GSH. All relevant information as outlined in Table 4.2 below was extracted from the patient's medical folder and then followed up periodically from admission to discharge. These periodic visits for new participants were usually performed on Tuesdays and Thursdays at the ASCI unit at GSH. Trauma admission books in C14 (GSH trauma) were checked to determine whether any patients with suspected SCI were admitted to GSH but were not booked into the ICU or ASCI ward for further management due to limited bed space. This process was repeated on every visit to ensure no cases were missed as patients who are stable with mild SCIs might be referred to other healthcare facilities following a period of observation.

The study's second phase determined the mortality of patients recruited into the incidence cohort. These patients were then followed up at one and two years post-injury to determine relevant outcomes pointing to health, functioning and mortality. However, vital status (i.e., whether the participant is alive or deceased or their vital status cannot be determined) was the sole outcome that could be assessed at one- and two-years post-injury owing to the challenges that were experienced when following up participants.

As seen in Table 4.2 below, data concerning the outcomes were measured at three points: within seven days of admission, seven days prior to discharge and one- and two-years post-injury. Discharge plans were usually made in advance by the spinal consultants within the unit, so this data was captured when the discharge letter was written up and placed in the participant's medical folder. However, in instances where the participant was discharged prior to collecting the required data, the medical folder was requested from the hospital's medical records unit to capture the outstanding data. In addition, the participants' medical folders were accessed while they were still in the ICU or general ward. Medical information from these records was used to determine patients' survival status at discharge, which accounts for in-hospital mortality.

Table 4.2 Data collected on admission to acute care, discharge from acute care, and one/two year follow up.

Admission	Discharge acute care	One and two-year follow up
Age	Survival status	Survival status (i.e., alive or deceased)
Gender	Days hospitalised	
Acute admission	Final inpatient discharge	
Injury aetiology	Secondary medical complications	
Vertebral injury	Neurological status	
Associated injury	Functional status (based on ASIA motor scores)	
Spinal injury	Ventilator assistance	
Ventilator assistance		
Neurological status		
Secondary medical complications		
Functional status (based on ASIA motor scores)		

In order to determine one-year mortality of participants, the initial strategy used was verbal autopsy. This entailed contacting the participant or primary caregiver to ascertain survival status and reason for death if the participant had died. This initial strategy proved unsuccessful due to the difficulties experienced in following up with participants after they were discharged. Patients often changed their contact numbers and place of residence, making it difficult to determine their vital status. Due to the challenges experienced with determining verbal autopsy, a second strategy was used. This entailed sourcing the information regarding vital status from the MRCs Burden of Disease Unit. Vital status was determined by sourcing patient identity numbers (ID) from GSH, which is a collaborator on the project. Once the participant's ID numbers were obtained from GSH, a clean excel spreadsheet reflecting only participant ID numbers were given to the MRCs Burden of Disease Unit to determine the vital status of all patients who demised within the first two-year post-injury. The unit has a death registry which is linked to the Department of Home Affairs. The UWC Biomedical Research Ethics Committee approved this method of determining vital status of patients following an amendment to the study's ethics. This was to ensure that all principles were followed with respect to the Protection of Personal Information (POPI) act 4 of 2013. All data were first captured and coded within Microsoft excel before being exported to IBM SPSS version 28 for statistical analysis (SPSS, 2016). However, to reduce the degree of loss to follow-up of participants, contact details (landline and cellphone numbers) and residential addresses were documented when patients were recruited into the study (Kim et al., 2018; Teague et al., 2018). In addition to documenting the contact details of participants, contact details and residential addresses of the next of kin and family members were also documented. Participants were contacted telephonically to gather follow-up data.

4.5.4 Data analysis

All data was first captured in a Microsoft excel spreadsheet and then transferred to SPSS version 28 for statistical analysis. Since assumptions for logistic regression analysis could not be filled with respect to identifying predictors of early mortality, the data analysis plan below was set up to deliver a preliminary descriptive healthcare decision making model. Due to this, mortality is reported as an absolute percentage. This was achieved by employing a retrospective cases series methodology of the eleven mortality cases who have demised within one year post-injury (see Chapter 6). For all inferential statistics, the alpha level was set at 0.05 with a power of 80% to identify any statistical significance between exposures and outcomes. Although statistical significance was important, aspects of clinical significance were made during the analysis concerning the presence of secondary complications and the total length of hospital stay. Clinical significance was defined as whether results were clinically relevant even if they were not statistically significant (Ranganathan et al., 2015).

Descriptive statistics such as means, standard deviations, and percentages were used

- To describe the characteristics (i.e., age, sex, aetiology, associated injuries, vertebral injuries, spinal surgery, length of hospital stay) of all tSCI participants who have sustained a tSCI enrolled in the cohort for an 18-month timeframe.
- To determine the timing of time-sensitive interventions related to the time to surgery; time to specialised care, which includes time to acute care from intermediate hospitalisations and time to rehabilitation. (*Based on another study conducted in the same geographical (Conradsson et al., 2019), the cut point in relation to time to surgery was set at three days, while a cut point of 35 days was set in relation to total length of hospital stay. The latter cut point is supported by*

existing literature in relation to the acute length of hospital stay (Burns, Santos, et al., 2017).

- To determine the injury factors (i.e., severity and associated injuries).
- To determine the risk indicators (i.e., comorbidities and secondary medical complications).
- To descriptively study the one-year mortality cases based on their key exposures in terms of success and failures.

In addition to describing the mortality cases using descriptive statistics, sensitivity analyses of all candidate exposures (i.e., age, gender, aetiology, intermittent hospitalisation, vertebral injury, secondary complications, associated injuries, time to surgery, ASIA classification on admission) were cross-tabulated against vital status at one year to determine the following:

- Sensitivity = $\frac{True\ positive}{True\ Positives + False\ Negatives}$,
- Specificity = $\frac{True\ Negatives}{True\ Negatives + False\ Positives}$,
- Positive predictive value = $\frac{True\ Positives}{True\ Positives + False\ Positives}$
- Negative predictive value = $\frac{True\ Negatives}{True\ Negatives + False\ Positives}$
- Prevalence = $\frac{Total\ number\ of\ cases}{Total\ population}$,

The prevalence of these candidate exposures was calculated to determine their influence on the positive and negative predictive values.

Inferential statistical tests included:

The chi-squared test was used primarily to:

- Determine any associations between demographic and injury characteristics and how they may have impacted the care processes of persons who sustained a tSCI. This is related to the objectives as outlined above.

Wilcoxon signed rank test and Welsch t-test was primarily used to:

- Determine neurological recovery at admission and discharge.
- Determine functional recovery at admission and discharge.

Binary logistic regression was used to:

- Determine factors which influenced the length of hospital stay and surgical status. All independent variables included in the regression analysis were assessed for multicollinearity. All condition indices were proven to be low. Low condition index scores indicate a low concern of multicollinearity between independent variables. Indices greater than 15 indicate a possible collinearity problem, while indices greater than 30 indicate a serious problem with collinearity. Concerning length of hospital stay, associations were noted between the independent variables which were surgical status (yes/no), ASIA A Classification on admission (yes/no) and tetraplegia (yes/no). Concerning surgery status (yes/no), associations were noted between male (yes/no) and MVA status (yes/no). "*The fact that some or all predictor variables are correlated among themselves does not, in general, inhibit* *our ability to obtain a good fit nor does it tend to affect inferences about mean responses or predictions of new observations (Kutner et al., 2004)."*

Listwise case deletion was performed using SPSS to cater for all missing data. Furthermore, data imputation for missing values was not considered as the assumption for "missing completely at random (MCAR) is not justified. Systematic differences may exist and be linked to exposures or outcomes.

4.6 ETHICAL CONSIDERATION

This doctoral degree formed part of a larger study being funded by the Medical Research Council of South Africa (SAMRC) that had clearance at an institutional (Ethics reference number BM/16/3/24), healthcare facility and governmental levels, respectively (See appendices 1 and 3). Ethical clearance for this degree was obtained from the UWC's Biomedical Medical Research Ethics Committee (Ethics reference number BM/18/1/17 – see Appendix 2). The research study incorporated aspects of good clinical practice as set out in the declaration of Helsinki (World Medical Association, 2013). Participants who met the eligibility criteria were required to sign an informed consent after being provided with full and accurate information. Participants were allowed to withdraw from the study at any time and were not negatively impacted if they chose to do so. The anonymity of all participants was maintained throughout the study by allocating each participant a record number. The study was considered low to medium risk since no intervention was administered at any stage. However, if in any way the participant was harmed, necessary counselling would have been provided by the healthcare practitioners on site. Mortality data obtained from the SAMRC's (South African Medical Research Council) Burden of

Disease Unit was considered public access and hence did not negatively impact the participant or their families in any way. Participant ID numbers were sourced from the attending acute hospital, Groote Schuur (specifically the ASCI UNIT), which is a dual collaborator on the project. All data is kept in a locked cabinet and on a password-protected laptop for five years. Data regarding this project was only accessible by the researcher and his supervisors.

CHAPTER FIVE

RESULTS

5.1 INTRODUCTION:

In this chapter, the researcher presents the results of the data relating to this traumatic spinal cord injury (tSCI) cohort according to sub-objectives that were outlined in chapter one and briefly summarised below. The results were further grouped according to the domains related to Krause's theoretical risk model and Donabedian's model of care to determine:

- the injury characteristics (i.e., age, sex, aetiology, associated injuries, vertebral injuries, severity, spinal surgery, length of hospital stay, severity and associated injuries) of all tSCI participants who have sustained a tSCI enrolled in the cohort for an 18-month time frame.
- time-sensitive interventions related to time to surgery from the onset of injury, time to specialised care from the onset of injury, which includes time to acute care from intermediate hospitalisations, and time to rehabilitation from admission to specialised acute care.
- the prevalence of risk indicators (comorbidities; secondary medical complications).
- the total length of hospital stay of the participants.
- neurological recovery at admission and discharge of the participants.
- functional recovery at admission and discharge of the participants.

5.2 CHARACTERISTICS OF THE STUDY SAMPLE

Data regarding patient demographics and injury characteristics for persons who had sustained a tSCI were analysed descriptively and is described in Table 5.1 below. Of the 167 participants who were included in this study, 86% (n=144) were males, while 14% (n=23) were females. This translates to a male-to-female ratio of 6.3:1. The mean age concerning onset of injury was 33.5 years with a standard deviation (s.d) of 11.9 years. Ages ranged from 18 years to 86 years, with 45% and 3% in the 18-30 and ≥61 age categories, respectively. The most common causes of spinal cord injury (SCI) in this cohort were because of assault (67%,110/167), which was followed by transport- (23%,38/110) and fall-related (8%,14/110) aetiology. Sport-related aetiology only accounted for 0.6% (1/167). Assault was broken down into gunshot, stabbing and blunt force trauma-related aetiology. Gunshot and stabbing-related aetiology accounted for 57% (63/110) and 35% (39/110) of assault cases, respectively, while blunt force trauma was minimal and only accounted for 4% (4/110) of the recorded assault cases. Transport-related injuries consisted of pedestrian-vehicle accidents (PVAs) (individuals who were struck by an oncoming motor vehicle or any other means of transportation) and motor vehicle accidents (MVAs) (either a passenger or driver of the motor vehicle). Overall, PVAs accounted for 24% (9/37), while MVAs contributed 76% (28/37). Seventy-seven per cent of patients presented with vertebral injuries on admission, while 65% of patients presented with associated injuries such as pneumothoraces, lung contusions, fractures of either the upper or lower limb and injury to visceral organs, to name but a few.

Table 5.1 Study population characteristics (N=167)

Gender (*n*; %)		
Male	144	86.2
Female	23	13.8
Ratio	6.3:1	
Age at injury (mean; s.d)	33.59	11.96
Age at injury (median; range)	31	18-86
Age categories (*n*; %)		
18-30	75	44.9
31-45	69	41.3
46-60	18	10.8
61 and older	5	3
Aetiology (*n*; %)		
Assault	110	65.9
Transport	37	22.2
Falls	14	8.4
Other traumatic causes	2	1.2
Sport	1	0.6
Missing	3	1.8
Associated injury (*n*; %)		
Yes	109	65.3
No	45	26.9
Missing	13	7.8

Vertebral injury (*n*; %)		
Yes	128	76.6
No	30	18
Missing	9	5.4
Secondary complications (*n*; %)		
Yes	48	28.7
No	77	46.1
Missing	42	25.1
Spinal surgery (*n*; %)		
Yes	47	28.1
No	101	60.5
Missing	19	11.4
Days to surgery (mean; s.d)	11	9.6
Days to surgery (median; range)	8	0-39
Duration of acute care in days (mean; s.d)	19.4	20.9
Duration of acute care in days (median; range)	12	0-103
Duration of ward care in days (mean; s.d)	28.7	25.5
Duration of ward care in days (median; range)	25	4-237
Duration of rehab in days (mean; s.d)	34.9	33.5
Duration of rehab in days (median; range)	29.5	0-259

ASIA class admission (*n*; %) *according to recommendations for the SCI core dataset*		
ASIA A	61	36.5
ASIA B	12	7.2
ASIA C	19	11.4
ASIA D	30	18
Missing (*n*; %)	45	26.9

5.3 INJURY FACTORS

5.3.1 Injury factor (Krause's theoretical risk model): Aetiology and area of residence

In total, 146 participants have data relating to the suburbs where their SCI occurred (see Figure 5.1). Suburbs with the largest number of injuries were Gugulethu (13%,19/146), Phillipi (12%,17/146) and Mitchells plain (8%,11/146). Of the 146 participants, only 141 have data relating to the place of injury (i.e., suburb) and gunshot/stabbing-related status (yes/no). Fifty-nine of the 141 participants who sustained their injuries as a result of gunshot-related aetiology came from Gugulethu (17%,10/59), Philippi (14%,8/59), and Mitchells plain (9%, 5/59). Thirty-five of the 141 participants who sustained their injuries as a result of stabbing-related aetiology came from the suburbs of Gugulethu (17%,6/35), Atlantis (11%,4/35) and Mitchells Plain (11%,4/35), respectively. Besides presenting with the second highest number of assault cases (10%,10/101), Phillipi (23%,7/31) also had the highest number of transport-related injuries.

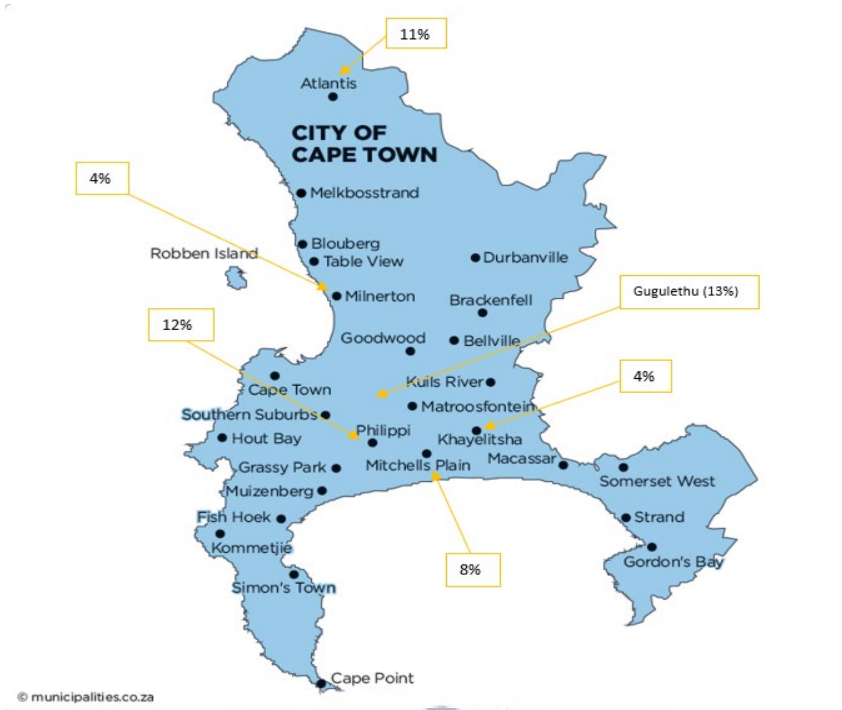


Figure 5.1 Areas with the highest occurrence of tSCI in the Cape Metropole

5.3.2 Injury factor (Krause's theoretical risk model): Aetiology and gender

In total, 110 participants had information relating to gender and assault status. Males accounted for 93% (n=102) of the total number of assault cases compared to females, with only 7% (n=8). Sixty-three patients sustained spinal cord injuries as a result of gunshot-related aetiology. Males accounted for the largest percentage (92.1%,58/63), while females accounted for only 7.9% (5/63). Of the 39 participants who sustained their injuries as a result of stabbing-related aetiology, males accounted for 97.4% (38/39) compared to females with 2.6% (1/39). A statistically significant association was found between stabbing status (yes/no) and gender (x^2= 5.845 df=1, p=0.01); however, this was not the case for gunshot status (yes/no) and gender (x^2=3.500, df=1, p=0.06).

In total, MVAs and PVAs accounted for 75.7% (n=28) and 24.3% (n=9) of transport-related cases, respectively. Males accounted for 68% (19/28) of the total MVA-related cases compared to females with 32% (9/28). Concerning PVA, males accounted for 78% (7/9) of the total PVA cases compared to females with 22% (2/9). There was no statistically significant association between PVA (yes/no) and gender (x^2=0.517, df=1, p=0.47); however, a statistically significant association was noted between MVA (yes/no) and gender (x^2=9.071, df=1, p=0.03).

5.3.3 Injury factor (Krause's theoretical risk model): Spinal injury level by gender

As seen in Figure 5.2 below, male patients formed the largest percentage of injuries at each spinal level, with the most affected area being the thoracic spine. However, the most affected area with respect to females was the cervical spine and the thoracic spine. No association was found between the spinal injury level and gender (x^2= 0,575 df = 2, p = 0.75).

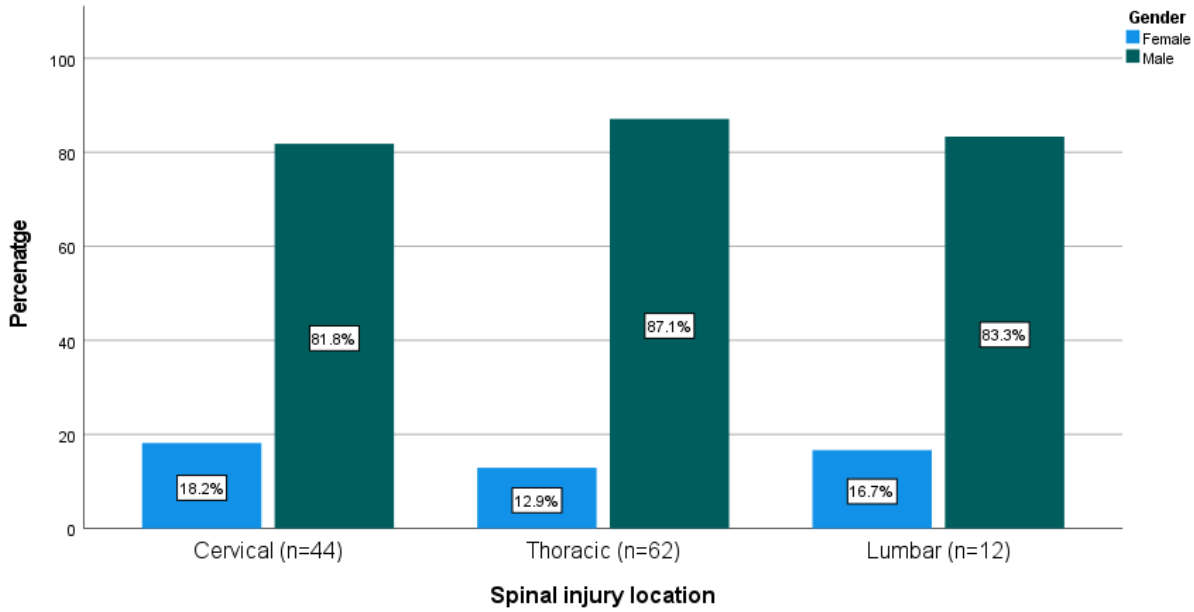


Figure 5.2 Spinal injury level by gender (n=118)

5.3.4 Injury factor (Krause's theoretical risk model): Aetiology and age

In total, 110 participants have information relating to age and aetiology. Stratified age categories of 18-30 (56%,62/110) and 31-45 (35.5%,39/110) years showed the highest percentage of SCI caused by assault. However, this trend carried over to the age category of 46-60 years (8.2%,9/110). In total, 39 participants sustained spinal injuries as a result of stabbing-related aetiology. The majority of stabbings took place in the age category of 18-30 years (66.7%,26/39) followed by the age categories of 31-45 years (30.8%,12/39) and 46-60 years (2.6%,1/39), respectively. Only four participants sustained injuries as a result of blunt force trauma. Two out of the four participants fell within the age category of 31-45, while the remaining two participants fell within the age categories of 18-30 and 46 -60 years, respectively. The main causes of tSCI in the age category 61 and older were transport and fall related. A statistically significant association was found between age categories and stabbing-related aetiology status (yes/no) (x^2=10.6811, df=3, p=0.01), indicating that patients in the age category of 18-30 years are associated with a higher frequency of stabbing-related injuries. However, no association was found between gunshot-related aetiology status (yes/no) and age categories (x^2=5.417, d=3, p=0.14).

Twenty-eight participants sustained spinal injuries due to MVAs. Fifty-seven per cent (16/28) of these participants fell within the age category of 31-45, while 29% (8/28) fell within the age category of 18-30 years. The remaining age categories of 46-60 and 61 years and older accounted for 7.1% (2/28) of injuries each. In total, 9 participants sustained spinal cord injuries due to pedestrian-related accidents. Forty-four per cent (4/9) of these injuries fell within the age category 31-45, while the age categories of 18-30 years and 46-60 years accounted for 22% (2/9) of pedestrian-related accidents each. In contrast, only one patient fell within the age category of 61 years and older. No statistically significant association was found between age categories and motor vehicle-related aetiology status (yes/no) (x^2=6.113, df = 3, p=0.10). This finding was the same when comparing pedestrian-related aetiology status (yes/no) to age categories (x^2= 4.647, df=3, p=0.2).

5.3.5 Injury factor (Krause's theoretical risk model): Aetiology and spinal injury level

In total, 44 participants sustained injuries because of gunshot-related aetiology and have information related to spinal injury level on admission. Fifty-two per cent (n=23) of injuries caused by gunshot-related aetiology occurred at the thoracic spine, which was followed by the cervical (29.5%,13/44) and lumbar spine (18.2%,8/44), respectively. Irrespective of aetiology, 118 participants had information related to spinal injury level. Spinal injuries to the thoracic spine were more common (53%, 62/118). This was followed by injuries to the cervical spine (37.3%, 44/118). The lumbar spine was the least common site of spinal injuries (10.2%,12/118). No injuries as a result of gunshot-related aetiology were noted at the sacral region.

A total of four participants sustained spinal injuries because of pedestrian-related aetiology and have information related to spinal injury level on admission. Two out of four injuries occurred at the thoracic spine, while the remaining injuries occurred at the cervical and lumbar spine. Regarding MVA, a total of 22 participants were included. Fifty per cent (11/22) of injuries occurred at the thoracic spine, with 50% (11/22) of injuries occurring at the cervical spine. No injuries were reported at the lumbar spine. Furthermore, no association was found between the mode of the transport-related injury (i.e., PVA/MVA status) and the location of the spinal injury (PVA: x^2=1.056, df=2, p=0.59)/(MVA: x^2= 3.909, df = 2, p=0.14).

5.3.6 Injury factor (Krause's theoretical risk model): American Spinal Injury Association (ASIA) classification and spinal injury level

In total, 122 participants had data available regarding ASIA classification on admission see Figure 5.3). Upon admission to the specialised spinal cord unit at Groote Schuur Hospital (GSH), 50% (61/122) of participants presented with an AISA classification of A (motor complete and sensory complete) followed by an AISA classification of D (motor and sensory incomplete), which accounted for 25% (30/122) participants.

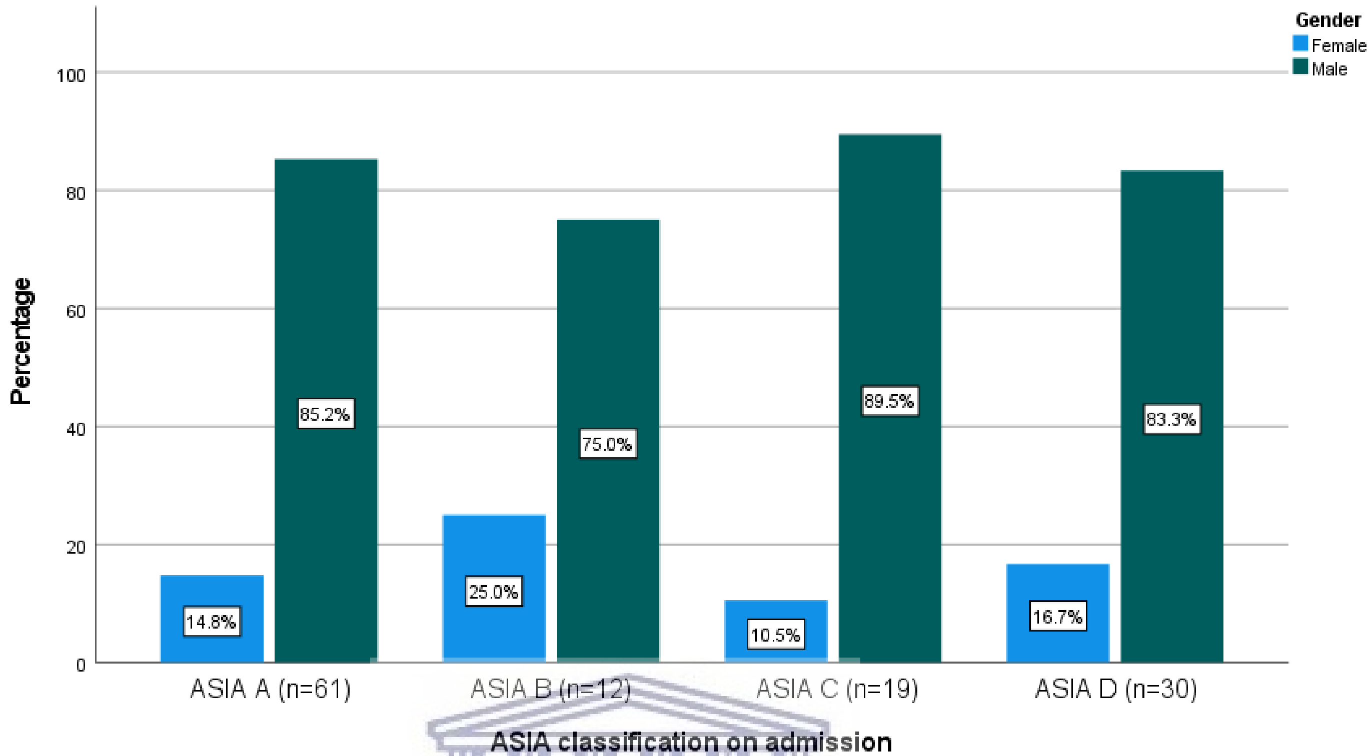


Figure 5.3 ASIA classification by gender (n=122)

One hundred and twenty-nine participants had information relating to the severity of SCI (i.e., completeness of injury). Forty-eight per cent of participants (62/129) were recorded as having a complete lesion on admission (i.e., ASIA A), while 52% (67/129) participants presented with incomplete spinal lesions (i.e., ASIA B, C and D) on admission. The highest percentage of participants classified as AISA A (motor complete and sensory complete) sustained injuries to either the thoracic (64%) or cervical spine (33%) (See Figure 5.4 below).

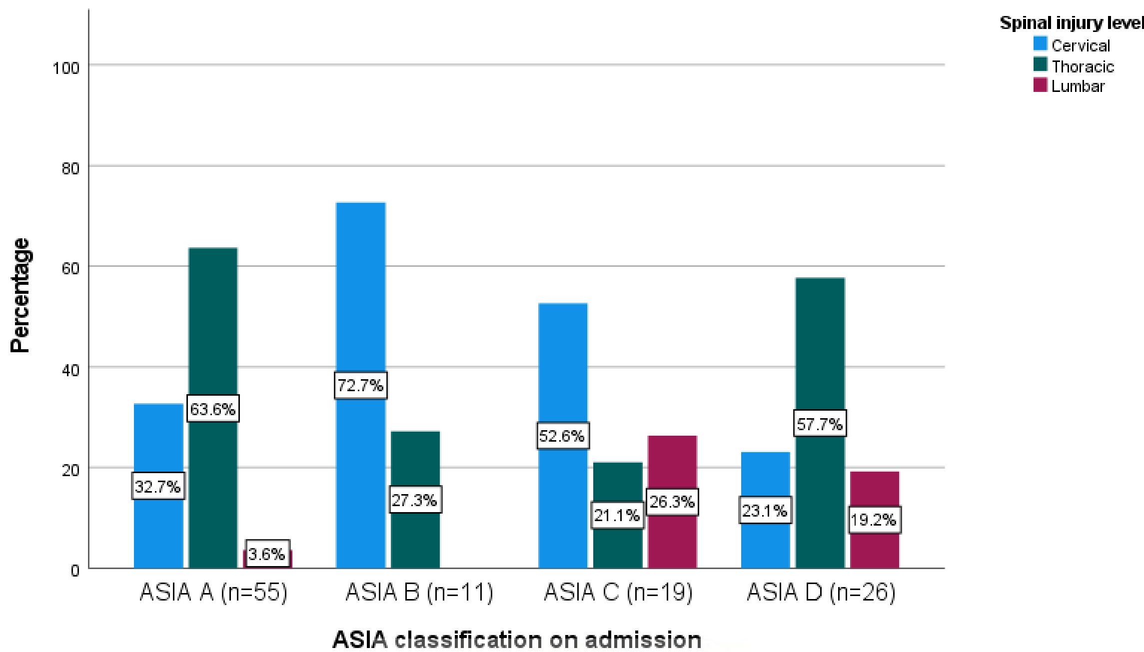


Figure 5.4 ASIA classification by spinal injury level (n =111)

In total, 50% (55/111) of participants were characterised as having complete lesions. Sixty-seven per cent (37/55) of participants who were defined as having complete lesions were characterised as being paraplegic, compared to those patients who were found to have complete lesions and were characterised as tetraplegic (32.7%,18/55). A statistically significant association was found between the ASIA classification on admission and the location of the spinal injury (x^2= 22.711, df=6, p<0.01).

5.3.7 Injury factor (Krause's theoretical risk model and Donabedian's model of care): Morbidity after tSCI (neurological and functional recovery)

In total, 109 participants had data pertaining to ASIA classification on admission and discharge. Of the 54 participants who recorded an ASIA A classification on admission, 96.3% (52/54) of the cases were discharged as an ASIA A, 1.9% (1/54) as an ASIA B, and 1.9% (1/54) as an ASIA C. Of the 11 participants who recorded an ASIA B on admission, 45.5% (5/11) were discharged as an ASIA B, 45.5% (5/11) as an ASIA C and as ASIA D in 9.1% (1/11) of the cases (see Table 5.2). Seventeen participants recorded an ASIA C classification on admission, 47.1% (8/17) were discharged as an ASIA C, and as ASIA D in 52.9% (9/17) of the cases. Of the 27 participants who recorded an ASIA D on admission, 85.2% (23/27) of the cases were discharged as an ASIA D and 14.8% (4/27) of cases as ASIA E. Using the Wilcoxon rank sum test, a statistically significant association ($P < 0.001$) was noted between motor and sensory scores on admission and discharge for the 85 participants who had data relating to motor and sensory scores on admission and discharge (See Table 5.3). As seen in Table 5.3, the mean scores for motor function were 25 (motor right) and 24 (motor left) but improved to 29 (motor right) and 29 (motor left) on discharge. Mean scores for sensory function were 65 (sensory right) and 67 (sensory left) on admission but improved to 76 (sensory right) and 74 (sensory left) on discharge.

Table 5.2 ASIA impairment scale on admission and discharge (n=109).

	On admission n (%)	ASIA A on discharge n (%)	ASIA B on discharge n (%)	ASIA C on discharge n (%)	ASIA D on discharge n (%)	ASIA E on discharge n (%)
ASIA A	54 (100%)	52 (96.3%)	1 (1.9%)	1(1.9%)		
ASIA B	11 (100%)		5 (45.5%)	5 (45.5%)	1 (9.1)	
ASIA C	17 (100%)			8 (47.1%)	9 (52.9%)	
ASIA D	27 (100%)				23 (85.2%)	4 (14.8%)
ASIA E	0 (0%)					0

Table 5.3 ASIA motor and sensory scores on admission and discharge (n=85) - Wilcoxon signed-rank test

	On admission (n=85)		**On discharge (n=85)**	**p-value**
	Mean (SD) Median (IQR)		Mean (SD) Median (IQR)	
Motor score (R) admission	25.4 (15.0) 25 (12.0- 37.0)	Motor score (R) discharge	28.9 (15.1) 25 (22.0 - 45.0)	**p < 0.001**
Motor score (L) admission	23.9 (14.7) 25 (9.5 – 35.0)	Motor score (L) discharge	28.5 (15.2) 25 (19.0 - 45.0)	**p < 0.001**
Sensory score (R) admission	65.1 (32.0) 66 (39.0 – 95.0)	Sensory score (R) discharge	76.2 (31.5) 82 (51.0 – 112.0)	**p < 0.001**
Sensory score (L) admission	66.5 (33.0) 66 (39.0 – 96.5)	Sensory score (L) discharge	74.4 (31.5) 80 (49.0- 104.5)	**p < 0.001**

IQR: Interquartile range; L= Left; R= Right

5.4 PROCESS MEASURES

5.4.1 Process measure (Donabedian's model of care): Time to acute care from intermediate hospitalisation

Fifty-nine participants had intermediary hospitalisation, defined as those who were not transferred directly to specialised care and acute care admission data. The mean time to acute care from admission to intermediate facilities for these patients was 3.25 days (s.d 6.2). The aetiologies with the highest percentage of intermittent hospitalisations were assault (54%,32/59) and transport-related (36%,21/59). In total, 23 participants experienced intermittent hospitalisation of ≥ 2 days. Participants within the age group of 31-45 years (61%,14/23) experienced longer periods of hospitalisation at intermediate care facilities prior to being admitted to acute care at GSH. This was followed by the age category of 18-30 years (34.8%, 8/23). Upon further analysis, a statistically significant association was found between aetiology and time to acute care admission from intermediate hospitalisation (x^2=13.841 df=3, $p<0.01$). When comparing patient age groups (x^2=6.638 df=3, p=0.84) and place of residence (x^2=27,840 df=22, p=0.18) to acute care admission from intermediate hospitalisation, no statistically significant association was found.

5.4.2 Process measure (Donabedian's model of care): Time to acute in-hospital physiotherapy treatment

In total, 83 participants had information relating to admission dates to GSH and admission dates to acute in-hospital physiotherapy. The mean time to acute in-hospital physiotherapy was 3.25 days (s.d 5.2) for the 83 patients. Acute in-hospital physiotherapy was defined as physiotherapy treatment received within the intensive care unit (ICU) and SCI ward and ranged from 0 to 42 days in length. Forty-one per cent of patients (41%, 34/83) received in-hospital physiotherapy treatment within one day after being admitted to acute care (See Figure 5.5).

Transport-related injuries comprised the largest percentage (53%,18/34) of participants who received physiotherapy treatment within one day after injury. This was followed by assault (32%,11/34) and fall (11.8%,4/34) related aetiology. Sport-related injuries accounted for (2.9%,1/34) of participants who received physiotherapy treatment within one day. Furthermore, a statistically significant association was noted between time to in-hospital rehabilitation and aetiology (x^2=22.029, df=4, p<0.01).

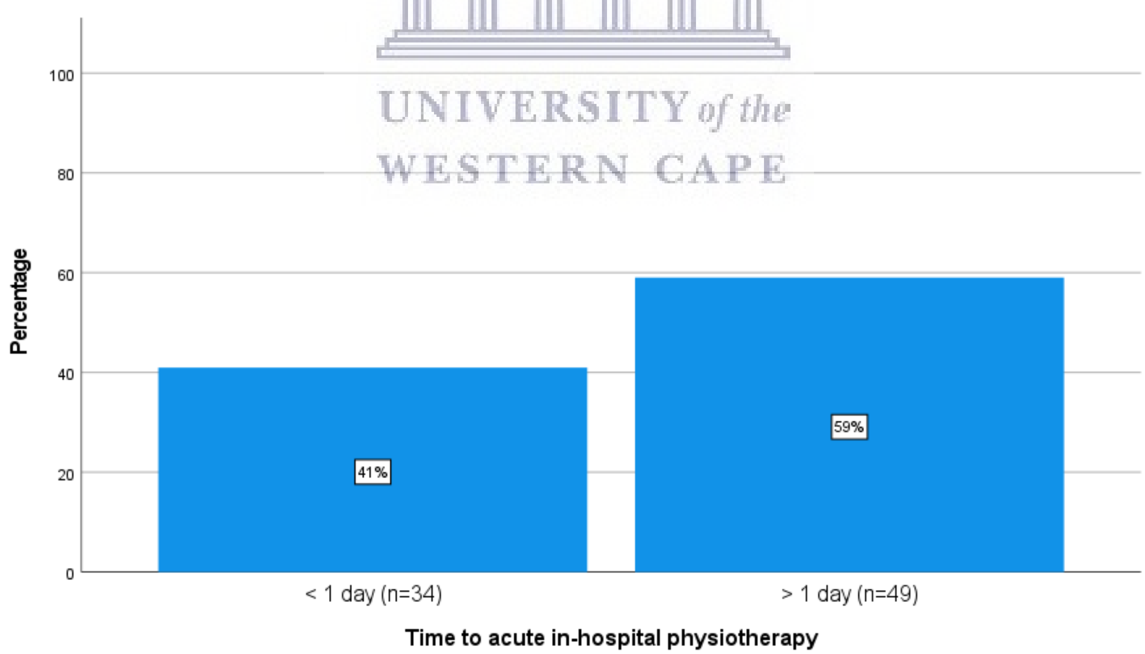


Figure 5.5 Time to acute in-hospital physiotherapy (days) (n=83)

5.4.3 Process measure (Donabedian's model of care): Aetiology and spinal surgery

Forty-seven participants underwent surgery and have information related to aetiology. Of those who underwent spinal surgery, 55% (26/47) had their injuries caused by transport-related aetiology, 23% (11/47) due to fall-related aetiology, 15% (7/47) due to assault-related aetiology and 4.3% (2/11) because of other traumatic causes. Seventy-two per cent (34/47) of patients requiring surgery were male, while 27.7% (13/47) were female. A statistically significant association was found between the aetiology of injury and spinal surgery (yes/no) (x^2=84.613, df=4, p<0.01), indicating that transport-related aetiology is associated with a higher frequency of spinal surgery.

5.4.4 Process measure (Donabedian's model of care): Injury factors and spinal surgery

The mean time to spinal surgery was 11 days (s.d 9.6 days) for 45 participants, with data related to the date of injury onset and time to spinal surgery. Of the 45 participants, 37 (82%) experienced a delayed time to spinal surgery (i.e.,> 3 days). The categories of 18-30 years (14%, 5/45,); 31-45 years (65%,23/45,) and 46-60 years (16%,6/45), all experienced longer times to surgery. Only 8 out of the 45 participants received surgery within three days. The age category of 31-45 years had the highest number of cases requiring surgical intervention (62%,28/45,). This was followed by the age categories of 46-60 (18%,8/45,) and 18-30 (16%,7/45), respectively. Participants within the age category of 61 and older recorded the lowest number of persons undergoing spinal surgery (4%,2/45,). No association was found between time to surgery and age groups (x^2= 1.509, df = 3, p=0.6). Overall, a statistically significant association was found between surgery status (yes/no) and right upper and lower limb ASIA motor scores on discharge (x^2=11.365, df=4, p=0.02). However, no association was found between spinal surgery status (yes/no) and left upper and lower limb ASIA motor scores on discharge (x^2=6.383, df=4, p=0.17). In addition, when combining left and right motor scores on discharge, no association was found with spinal surgery status (yes/no) (x^2=5.678, df = 4, p=0.22).

Survival status at one year was only available for 36 of the 45 (80%) participants with data relating to the time to spinal surgery. Eighty-three per cent of participants (30/36) who were alive one year post-injury underwent spinal surgery at GSH, compared to 97% (65/67) who were alive but did not receive any spinal surgery. Six out of eight participants received spinal surgery but did not survive one year post-injury compared to two patients who did not receive spinal surgery but passed away. A significant association was found between spine surgery status (yes/no) and survival status (yes/no) at one year (x^2= 6.119, d =1, p=0.01). Meaning, undergoing spinal surgery is associated with a reduced chance of survival at one year post-injury.

Transport-related injuries were the most common mechanism of injury requiring spinal surgery. Of the 45 participants who underwent surgery, 58% (n=26) were transport related, 22% (n=10) were fall related, 13% (n=6) were assault related, and 2% (n=1) was sports related. Other traumatic causes accounted for 4% (n=2). The main aetiologies related to delayed surgery (n=37) were transport (60%, 22/37) and fall-related aetiologies (22%, 8/37). Contrary to the finding above, a statistically significant association was found between time to surgery and aetiology (x^2= 37.712, df = 12, p < 0.01).

Data regarding the severity of injury (i.e., completeness) was available on 42 of the 45 (93%) participants who had time to spinal surgery data. Fifty-six per cent (n=25) of participants were classified as complete lesions, while 38% (n=17) were classified as incomplete lesions on admission. However, on discharge, the percentage of complete lesions dropped to 49% (n=22), and the percentage of incomplete lesions increased to 44% (n=20).

5.4.4.1 Process measure (Donabedian's model of care): Spinal surgery and sensory and motor changes

As seen in tables 5.4 and 5.5, only 27 participants who underwent surgery (60%,27/45) had data related to the level and severity of spinal injury and ASIA scores (i.e., motor and sensory) on admission. Those participants who were classified as having incomplete lesions on admission and underwent surgery showed greater improvements in mean motor and sensory scores at discharge than when compared to patients who were classified as having complete lesions on admission. Regarding the level of injury, patients with paraplegia on admission showed greater improvements in mean motor and sensory scores at discharge than when compared to those with tetraplegia on admission. Although this is the case, no statistically significant association was found between the groups (i.e., tetraplegic vs paraplegic)

Table 5.4 Mean differences in motor and sensory scores (n=27)

	Severity of injury on admission	Number of patients	Mean discharge scores	Standard deviation	95% Confidence interval for mean		P -value
					Lower bound	Upper bound	
Sensory score (L)	Complete	14	51,29	24,631	37,06	65,51	**P < 0.01**
	Incomplete	12	90,75	21,093	77,35	104,15	
Sensory score (R)	Complete	14	69,50	23,231	37,59	64,41	**P < 0.01**
	Incomplete	12	51,00	21,396	78,24	105,43	
Motor score (R)	Complete	14	91,83	9,427	13,20	24,09	**P < 0.01**
	Incomplete	12	69,85	13,315	22,29	39,21	
Motor score (L)	Complete	14	18,64	2,299	14,25	24,18	**P = 0.03**
	Incomplete	12	30,75	5,261	20,00	43,16	

Table 5.5 Mean differences in motor and sensory scores at discharge (n=27)

	Level of injury on admission	Number of patients	Mean discharge scores	Standard deviation	95% Confidence interval for mean		P -value
					Lower bound	Upper bound	
Sensory score (L)	Tetraplegic	13	64.00	34.392	43.22	84.78	P = 0.36
	Paraplegic	13	75.00	25.599	59.53	90.47	
Sensory score (R)	Tetraplegic	14	61.21	38.077	39.23	83.20	P = 0.31
	Paraplegic	13	73.92	24.700	59.00	88.85	
Motor score (R)	Tetraplegic	14	18.79	14.672	10.31	27.26	**P = 0.03**
	Paraplegic	13	29.15	7.493	24.63	33.68	
Motor score (L)	Tetraplegic	14	20.00	17.142	10.10	29.90	**P = 0.06**
	Paraplegic	13	30.23	9.479	24.50	35.96	

Following binary logistic regression (see Table 5.6), the following predictors were the only variables which were found to have a positive association in relation to surgical status (yes/no): Male (yes/no) and MVA status. For each unit increase in gender (i.e., from females to male) and MVAs status, surgical status increased by 216% and 1930%, respectively. The overall model was shown to have a good fit after using the Hosmer and Lemeshow Goodness of fit test (P=0.66). In addition, the area under the curve (AUC) showed excellent discrimination (AUC=0.75). This, in effect, means that the model can accurately discriminate 75% of the cases.

Table 5.6 Variables influencing surgical status following binary regression (n=147).

Predictors	Odds ratio	Condition index	95% CI		P-value
Gender: Male (Reference)	3.16	1.62	1.05	9.47	**P = 0.04**
Aetiology: MVA (Reference)	20.30	1.76	6.29	65.44	**P < 0.01**

CI: Confidence interval

5.4.5 Process measure (Donabedian's model of care): Secondary medical complications

Thirty-nine per cent of participants (48/125) developed secondary medical complications during acute care hospitalisation. As seen in Table 5.7 below, the four most prevalent secondary complications that participants developed during acute care hospitalisation are pressure ulcers (14%,17/125), pneumonia (12%,15/125), neuropathic pain (11%,14/125) and urinary tract infections (UTIs) (5%,6/125). Thirty-one (65%,31/48,) participants presented with one complication, 16/48 (33%) with two complications and 1/48 (2%) with four complications. For those participants who underwent surgery and had information relating to secondary medical complications (n=43), 58% (25/43) presented with secondary medical complications during their hospitalisation, compared to (42%,18/43) who did not. The four most prevalent secondary medical complications found in participants who underwent spinal surgery were neuropathic pain (16%,7/43), pressure ulcers (16%,7/43), pneumonia (16%,7/43,) and UTIs (7%,3/43).

Table 5.7 Prevalence of secondary complications (n=125)

Secondary medical complication	Acute care n (%)
Pressure ulcers	17 (14)
Pneumonia	15 (12)
Neuropathic pain	14 (11)
Urinary tract infections	6 (5)
Spasticity	3 (2)
Auto dysreflexia	1 (0.8)
Deep vein thrombosis	1 (0.8)

As seen in Table 5.8 below, no associations were found between the level of the injury and pressure ulcers (x^2=0.839, df=1, p=0.36), pneumonia (x^2=0.604, df=1, p=0.43), neuropathic pain (x^2=0.103, df=1, p=0.74) and UTIs (x^2=0.186, df=1, p=0.66). No statistically significant association was found in relation to the number of medical complications and the level of injury on admission (i.e., tetraplegic vs paraplegic) (x^2= 0.719, df=1, p=0.39).

Table 5.8 The number and type of secondary medical complications with respect to the level of injury (n=111).

Variable n	Tetraplegia	Paraplegia	p-value
Any complication			0.11
Yes	21	22	
No	23	44	
Number of complications			0.39
Zero or 1	37	60	
Two or more	7	7	
Pneumonia			0.43
Yes	6	6	
No	38	61	
Pressure ulcer			0.36
Yes	8	8	
No	36	59	
Neuropathic pain			0.74
Yes	5	9	
No	39	58	
UTI			0.66

Yes	2	2	
No	42	65	

*UTI: Urinary tract infection

As seen in Table 5.9, a statistically significant association was also found between any secondary medical complication and the completeness of the injury on admission (x^2= 8.540, df=1, p<0.01). Furthermore, the presence of specific secondary medical complications such as pneumonia (x^2=7.880, df=1, p<0.01) and UTIs (x^2=6.073, df=1, p=0.01) proved to have a statistically significant association with respect to the completeness of injury on admission (see Table 5.9). No statistically significant association was found in relation to neuropathic pain (x^2=0.704, df=1, p=0.40), pressure ulcers (x^2=0.748, df=1, p=0.38) and number of complications (x^2=0.748, df=1, p=0.38)

Table 5.9 The number and type of secondary medical complications with respect to the severity of injury (n=119).

Variable, n	Complete	Incomplete	p-value
Any complication			**< 0.01**
Yes	29	17	
No	26	47	
Number of complications			0.38
Zero or 1	46	57	
Two or more	9	7	
Pneumonia			**< 0.01**

Yes	12	3	
No	43	61	
Pressure ulcer			0.38
Yes	9	7	
No	46	57	
Neuropathic pain			0.40
Yes	5	9	
No	50	55	
UTIS			**< 0.01**
Yes	5	0	
No	50	64	

*UTI: Urinary tract infection

In addition, a significant association (x^2=8.486, df=1, p<0.01) was found for UTIs and vital status at one year (see Table 5.10). This was the same for any secondary medical complication and vital status at one year. No further associations were found with respect to the remaining secondary complications and vital status at one year.

Table 5.10 The number and type of secondary medical complications during acute care (n=88).

	Alive at one year		p-value
Variable n	**No**	**Yes**	
Any complication			**0.04**
Yes	6	31	
No	2	49	
Number of complications			0.13
Zero or 1	5	67	
Two or more	3	13	
Pneumonia			0.32
Yes	2	10	
No	6	70	
Pressure ulcer			0.53
Yes	2	13	
No	6	67	
UTI			
Yes	2	2	**0.00**
No	6	78	
Neuropathic pain			
Yes	1	11	0.92
No	7	69	

*UTI: Urinary tract infection

5.4.6 Process measure (Donabedian's model of care): Length of acute care stay (ICU/high care)

The total length of acute care stay included 103 participants (see Figure 5.6). These participants had a mean length of acute care stay of 19.49 days within the ICU or high-care wards. The length of acute stays ranged from 0-103 days with a standard deviation of 21 days. As seen in Figure 5.6, males had an increased length of acute care stays compared to their female counterparts. A significant association was noted between stabbing status (yes/no) and acute ICU/high care stays (x^2=15.956, df=3, p=0.01), however, no significant association was found between gunshot status (yes/no) and acute ICU/high care stays (x^2=0.939, df=3, p=0.81). Furthermore, no significant association was found between acute length of hospital stay and MVAs (x^2=4.640, df=3, p=0.20) and acute length of hospital stay and PVAs (x^2=6.148, df=3, p=0.10)

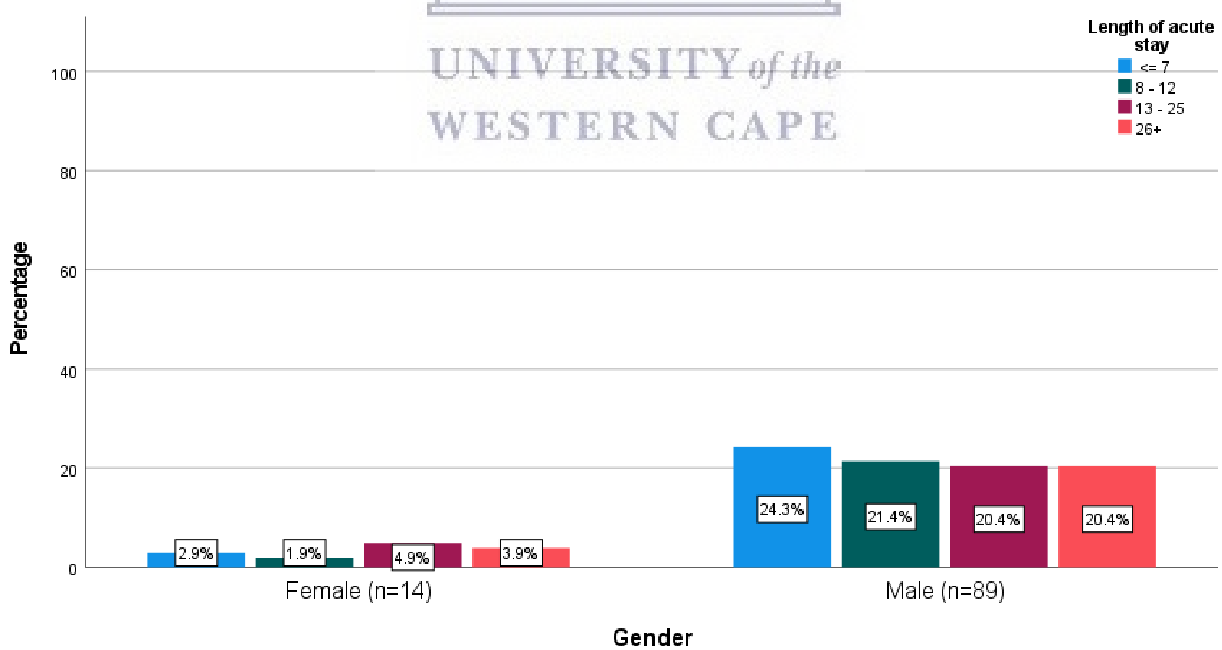


Figure 5.6 Gender by length of acute stay (n=103)

5.4.7 Process measure (Donabedian's model of care): Total length of hospital stay

One hundred sixteen participants had data relating to the total length of hospital stay. The total length of hospital stays for these 116 participants ranged from 0 to 267 days with a mean length of stay of 42.6 days (s.d 32.7days). Of the 116 participants, only 106 had data relating to secondary medical complications and the total length of hospital stay. Fifty-nine per cent of participants (63/106) did not present with any form of secondary complication during their hospital stay.

When the length of the hospital stay was dichotomised ≤35 days or 36+ days, participants who developed pressures ulcers (x^2=6.926, df=1, p<0.01), pneumonia (x^2=4.002, df=1, p=0.04), neuropathic pain (x^2=4.002, df=1, p=0.04) and UTIs (x^2= 5.053, df = 1, p=0.02) had on average longer hospital stays. A larger percentage of participants presenting with tetraplegia on admission experienced an extended duration of hospital stay compared to those who were classified as people with paraplegia (see Figure 5.7). In addition, those participants who were classified as having a complete spinal lesion on admission (i.e., AISA A) had a higher percentage of participants experiencing an increased length of hospital stay (i.e., ≥ 36 days) compared to patients with an AISA B, C or D (see Figure 5.8).

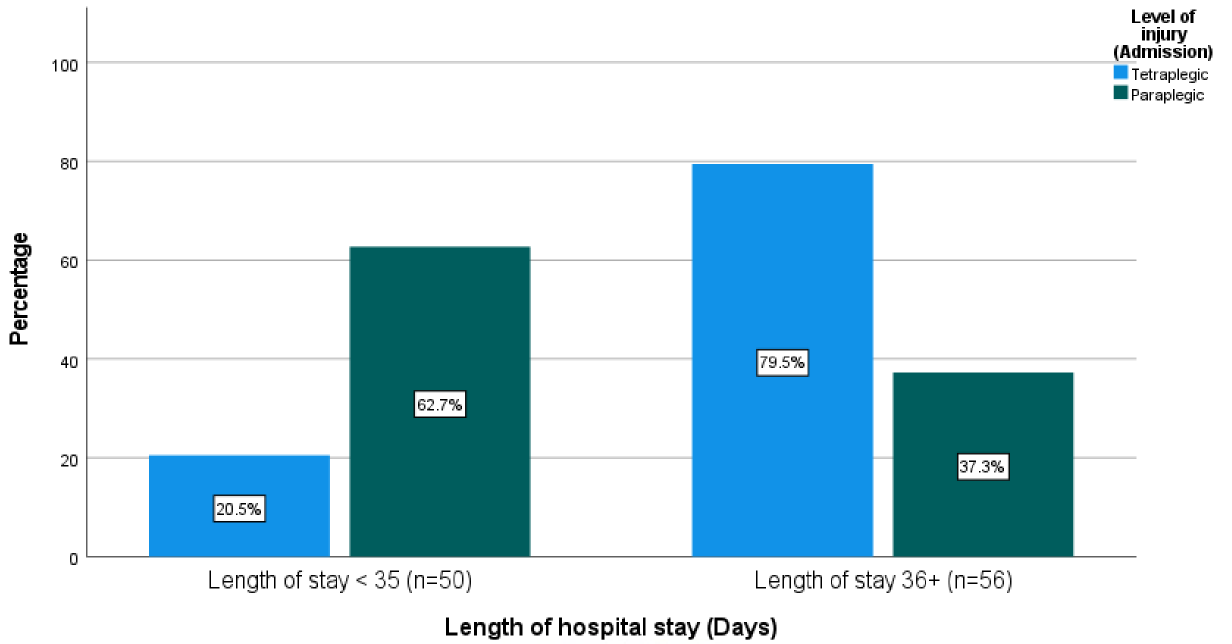


Figure 5.7 Total length of hospital stay by level of injury (n=106)

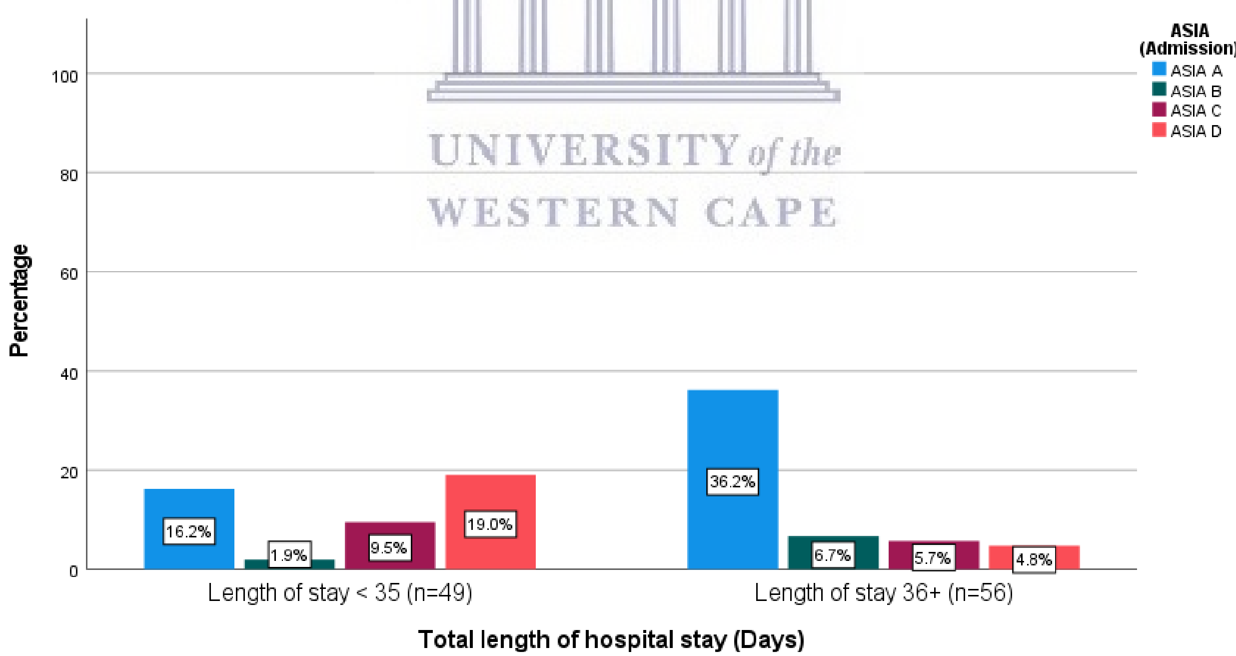


Figure 5.8 Total length of hospital stay by ASIA classification on admission (n=105)

Following binary logistic regression (see Table 5.11), the following predictors were the only variables that were found to have a positive association in relation to an increased length of hospital stay: spinal surgery status (yes/no), ASIA A classification on admission (yes/no) and level of injury (i.e., tetraplegic) (yes/no). This means that all three of the variables mentioned above increased the odds of experiencing an extended length of hospital stay. For each unit increase in spinal surgery, ASIA A classification and level of injury, the total length of hospital stay increased by 229%, 389%, and 793%, respectively. The overall model was shown to have a good fit after using the Hosmer and Lemeshow Goodness of fit test (P=0.79). In addition, the AUC showed excellent discrimination (AUC=0.82). This, in effect, means that the model can accurately discriminate 82% of the cases in relation to the length of hospital stay.

Table 5.11 Variables influencing total length of hospital stay following binary regression (n=96).

Predictors	Odds ratio	Condition index	95% CI		P-value
Spine surgery	3.29	2.13	1.15	9.42	**P = 0.02**
AIS A classification	4.89	2.37	1.69	14.19	**P < 0.01**
Tetraplegic	8.93	3.55	2.84	28.08	**P < 0.01**

CI: Confidence interval

5.7.8 Process measure (Donabedian's model of care): Length of acute in-hospital rehabilitation

Ninety-eight participants had data available with respect to the length of acute in-hospital rehabilitation. The length of acute rehabilitation was dichotomised ≤ 30 days or ≥ 31 days. The average number of days participants were admitted to acute in-hospital rehabilitation was 35. This ranged from 0 to 259 days with an s.d of 33.5 days. Of the 98 participants, 49 experienced an extended duration of rehabilitation. Spinal injuries, which were sustained as a result of assault-related aetiologies (stabbing: 3/49, Gunshot: 17/49 and blunt force trauma: 3/49) had a higher percentage (47%,23/49) of participants experiencing longer acute inpatient rehabilitation (i.e., ≥ 31days). This was followed by transport- (45%, 22/49) and fall- (8.2%, 4/49) related aetiology, respectively. A statistically significant association was found between total length of acute in-hospital rehabilitation and stabbing status (yes/no) (x^2=16.016, df=1, p<0.01), MVA status (yes/no) (x^2=11.153, df=1, p<0.01) and PVA status (yes/no) (x^2=4.087, df=1, p=0.04). No statistically significant association was found to exist between gunshot-related aetiology status (yes/no) and length of acute in-hospital rehabilitation (x^2=0.083, df=1, p=0.77).

5.5 SUMMARY OF RESULTS

The main findings of this study were grouped according to the domains of Krause's theoretical risk model and Donabedian's model of care

5.5.1 Domains related to Krause's theoretical risk model

Of the 167 participants who were included in this study, 86.2% of participants were males. This translated to a male-to-female ratio of 6.3:1. The most common cause of tSCI in this cohort was assault (65.9%). A large percentage of patients (76.6%) also presented with vertebral injuries on admission. These vertebral injuries were more prevalent at the thoracic spine (37.1%). Those admitted with tSCI also presented with a high percentage of concomitant injuries (65%). Lastly, a statistically significant association ($P< 0.01$) was noted regarding neurological and functional recovery between motor and sensory scores on admission and discharge. The mean scores for motor function on both the left and right showed improvements at discharge from admission. The same finding was noted with respect to left and right sensory scores at discharge. Concerning ASIA conversion from admission to discharge, those who were classified as an ASIA C on admission showed the greatest percentage of conversion compared to other ASIA grades.

5.5.2 Process measures as per Donabedian's model of care

Regarding time-sensitive measures, the following was found: The average time to surgery was 11 days (s.d 9.6 days). Transport-related injuries contributed towards the highest percentage of patients requiring spinal surgery. In addition, a statistically significant association was found between spine surgery status (yes/no) and survival status (yes/no) at one year (x^2=6.119, df=1, p=0.01). The mean time to acute in-hospital physiotherapy was 3.25 days (s.d 5.2). A statistically significant association was noted between time to in-hospital rehabilitation and the mechanism of injury (x^2=22.029, df=4, p<0.01), thus indicating an association between transport-related injuries and the time to acute in-hospital rehabilitation. The mean time to acute care from admission to intermediate facilities was 3.25 days (s.d 6.2 days). Transport-related aetiology experienced longer periods of hospitalisation at intermediate care facilities prior to being admitted to acute care at GSH. Overall, participants spent on average 42.6 days (s.d 32.7days) in GSH after sustaining their SCI while receiving medical care. Participants who were classified as having a complete spinal lesion on admission (i.e., AISA A) experienced longer periods of time in the hospital. An ASIA A classification on admission, spinal surgery status (yes/no) and level of injury (i.e., tetraplegic [yes/no]) were found to influence the total length of hospital stay positively.

CHAPTER SIX

SURVIVAL MODEL

6.1 INTRODUCTION

In this chapter, the researcher provides the baseline characteristics of all reported mortality cases who died within the first and second year post-injury. Their characteristics are tabulated against those of the survivor group (see Table 6.1). This is in line with objective1.5.1 which sought to descriptively study the reported mortality cases based on their key exposures (see Table 6.2) in terms of successes and failures (i.e., whether exposures were present and whether they were aligned to the best available evidence), while a concept map helped to illustrate the various linkages between exposures. These candidate exposures identified in Chapter 3 (i.e., age, gender, aetiology, intermittent hospitalisation, vertebral injury, secondary complications, associated injuries, time to surgery, American Spinal Injury Association (ASIA) classification on admission) were tabulated for each of the mortality cases in the first, and second year post-injury. These successes and failures were described narratively, providing primary evidence to support systems strengthening. In addition, a sensitivity analysis was performed on all exposures included in Table 6.3 to determine their predictability of vital status (i.e., alive or not) at one year. Lastly, Donabedian's model of care and Krause's Theoretical Risk Model was used to group these factors under specific domains. Further discussion for this chapter will take place in Chapter 7.

6.2 CASE SERIES METHODOLOGY

A descriptive retrospective case series methodology was used in the write-up of this chapter. The reason this research design was chosen is because it allows the researcher to summarise the participants clinical pathways they followed and highlight the factors that may have impacted on mortality (Kooistra et al., 2009). In addition, the low number of fatalities identified in relation to the one and two-year mortality cases, and the assumptions for regression analysis that were not able to be met, were also determining factors for the design that was chosen for this chapter. All demographic and clinical data related to the participants' care pathway were reviewed. The data included body mass index (BMI), aetiology, intermittent hospitalisation, vertebral injuries, secondary complications, associated injuries, time to surgery, acute in-hospital physiotherapy, ASIA on admission, and length of hospital stay. To avoid confounding, a gender and age category matching method was used to randomly match the one-year mortality group with participants in the survival group (De Graaf et al., 2011). This matching process was performed retrospectively and was used to determine whether those in the mortality group experienced a higher number of candidate exposures as opposed to those in the survival group. As noted above, data analysis was performed using descriptive statistics while each case was narratively described and discussed

6.2.1 Inclusion criteria

- All patients who demised within their first year post-onset of injury
- All patients who demised within the second year post-onset of injury

6.2.2 Exclusion criteria

- None

6.2.3 Data collection

All data used in this case series was collected using the spinal cord injury (SCI) core basic data set form, which is outlined in section 4.5.1.1

6.3 CHARACTERISTICS OF THE ONE-YEAR (n=11) AND TWO-YEAR MORTALITY (n=6) COHORT (SEE TABLE 6.2)

6.3.1 Age

Of the 11 reported cases (see Table 6.1) who did not survive one year post-injury, 7 patients (64%) fell within the age category of 31- 45, 2 (18.2%) in the age category of 46-60 and 2 (18.2%) within the age category of 61 and above. Patients who demised within the second year post-injury fell within the age categories of 18-30 (n=2), 31-45 (n=5) and 46 -60 (n=1). However, compared to the overall sample, patients within the age category of 31-45 years only had the second highest percentage of tSCI, with patients in the age category of 18-30 years presenting with the highest. In the one-year mortality group, age ranged from 32-80 years, while age in the second-year mortality group ranged from 21-46 years. The age of patients who survived post injury ranged from 18-86 years. The largest percentage of survivors fell within the age categories of 18-30 (52%, 51/99;) and 31-45 years (39%, 38/99)

6.3.2 Aetiology

As seen in Table 6.1, the main causes of injury in the one-year mortality cases were falls (n=4), assault (n=3) and transport-related aetiology (n=3). While in the second-year post-injury assault and transport-related injuries were the most common causes. However, in the survivor group the main causes of injury was assault (67.6%, 71/105) transport (24.8%, 26/105) and fall (5.7%, 6/105) related aetiology. Three of the four cases in the one-year mortality group who were injured as a result of falls sustained their injuries after falling from a height. Assault was further broken down into gunshot and stabbing-related aetiologies, with 2 out of the 11 cases who demised within the first year post-injury, sustaining injuries as a result of gunshot aetiology. The remaining patient sustained injuries due to stabbing-related aetiology. Stabbing- and gunshot-related aetiology in the second year post-injury, accounted for one mortality case each. Transport-related injuries (n=4) within the first year post-injury included those patients who were pedestrians (n=2) and those who were passengers (n=2). Those cases in the second-year mortality grouping who died as a result of transport related injuries were a passenger and driver. Transport-related injuries were the second most common cause of injuries in the one-year, two-year and survivor group. Based on the above, fall-related injuries were the most common cause of injuries in the one-year mortality group compared to the two-year mortality and the survivor group, where the main cause of injury was assault related.

6.3.3 Associated injuries

As seen in Table 6.1, associated injuries (presented with on admission to acute care) in the one-year mortality cases included haemothoraces (n=2); haemopneumothorax (n=1); laceration to the scalp (n=1); degloving of the lower back (n=1); mild traumatic brain injury

(TBI) (n=1); lung contusion (n=1); lung laceration (n=1); small bowel injury (n=1); fractures of the, ribs (n=3); fracture of the iliac wing (n=1) and L4/L5 haematoma (n=1). The two-year mortality cases presented with pneumothoraces (n=3); haemothoraces (n=2); lung contusion (n=1); haematoma axilla(n=1); grade 3 liver injury (n=1); grade 1 pancreatic injury; fractures to the ulnar (n=1), radius (n=1), fibula (n=1), clavicle (n=1), metatarsals (n=1) and ribs (n=3); stabs wound to the neck, back and flank (n=1) and shoulder dislocation (n=1). Associated injuries noted in both groups of mortality cases were also prevalent in the group of survivors, with all three groups presenting with a substantial percentage associated injuries on admission to the specialised unit.

6.3.4 Secondary medical complications

As seen in Table 6.1, secondary medical complications (which patients developed during hospitalisation) in the one-year mortality cases included pressure ulcers (n=3); UTIs (n=2); ventilator-acquired pneumonia (n=1); pulmonary oedema (n=1); lung embolism (n=1); atelectasis (n=1); seizures (n=1) and anemia (n=1). Furthermore, four of the mortality cases presented with two or more complication during their hospital stay. Two of the eleven mortality cases presented with no secondary medical complications during the period of hospitalisation, while data on two cases were missing. In the second-year mortality cases, only one patient had data concerning secondary medical complications. Two of the six case developed no complications, while data was missing concerning the remaining two. From the 99 survivors only 76 had data relating secondary medical complications. Thirty-nine percent (30/76) of survivors developed complications during their period of hospitalisation with 61% (46/76) presenting with no complications. The three most prevalent complications in the survivor group were: pressure ulcers (17%, 13/76), pneumonia (12%,9/76) and neuropathic pain (15%, 11/76).

6.3.5 Neurological level

Regarding the single neurological level of injury on admission, only 6 of the 11 cases who demised within the first year post-injury had information relating to the neurological level (see Table 6.1). Two cases had a single neurological level of C3, while two separate cases had a neurological level of C4 and C5, respectively. The remaining two cases had a neurological level of injury at the level of T11 and L2. Regarding those cases (n=6) who died in the second year post-injury, only three had information relating to the single neurological level of injury. These injuries were at the levels of C5, T2 and T7, respectively. From the above, it was noted that those who passed away in the first year of injury had a higher percentage of a single neurological lesion in the cervical spine region on admission compared to those who died two years post-injury.

Of the 11 patients in the one-year mortality group, only 8 had information relating to the neurological level of injury compared to the 5 in the second-year mortality group. In the one-year mortality cases, 4 (50%) were classified as paraplegics and 4 (50%) as tetraplegics on admission to Groote Schuur Hospital (GSH). Regarding the second-year mortality cases, only one patient was classified as a tetraplegic compared to four who were classified as paraplegic. The survivor group had a similar trend as the second-year mortality group, whereby a larger percentage of persons were classified as paraplegics (59.7%, 43/72) as opposed to tetraplegics (40.3%, 29/72) on admission.

In the one-year mortality group, the most common segmental level amongst patients who sustained cervical spine injuries occurred at levels C3 – C7 (n=3), while thoracic spine injuries occurred at levels T1 -T3 (n=3) and T11-T12 (n=1), respectively. Only one patient reported an injury at the level of L4/5, while one patient presented with no vertebral injuries on admission. However, in the second-year mortality group, two patients sustained injuries to the cervical spine (i.e., C2-C7), while the remaining three patients sustained injuries to the thoracic spine (i.e., T3 – T5). With respect to the survivor group, injuries to the thoracic spine were the most common followed by injuries to the cervical spine. Overlap with respect to the injury site was only present in one case in the first-year mortality cohort. As highlighted above, cervical and thoracic spine injuries were the most prevalent in one-year mortality, two-year mortality, and survivor groupings.

6.3.6 Time to surgery

On average, patients who underwent surgery waited on average 6.8 days (s.d 5.2 days) before receiving any form of surgical intervention (See Table 6.1). Time to surgery in the one-year mortality group ranged from 1- 4 days post-injury, with only two participants receiving surgery within three days (one and two days, respectively) post-injury, while time to surgery in the second-year mortality cases ranged from 5-21 days in length. In the one-year mortality cases, the mean time to surgery was 6.8 days (s.d 5.2 days), while in patients who demised in the second year post-injury, the mean time to surgery was 14.6 days (s.d 8.5 days) before receiving surgery. Mean time to surgery in the survival group was 10.8 days (s.d 9.4 days). The mean time to surgery was the least when compared to the one-year mortality and survivor groupings. However, time to surgery was the longest for those in the second-year mortality grouping.

6.3.7 ASIA classification on admission

Regarding ASIA classification, only data for (6/11; 55%) patients who were demised were present (See Table 6.1). On admission, these six patients were classified as an ASIA A (i.e., complete lesion). The same trend was found in those patients who passed away in the second year post-injury, with four (4/6; 67%) being classified as an ASIA A on admission. Those in the survivor group also had a high percentage of patients (37/79; 47%) presenting with an ASIA A classification on admission.

6.3.8 Length of hospital stay

The mean length of hospital stays for the one-year mortality cases were 92.7 days (s.d 82.5 days) (See Table 6.1). The total length of hospital stay ranged from 19-267 days. However, there was one outlier which recorded a total length of hospital stay of 267 days. Length of hospital stay for the second-year mortality cases had a mean of 58 days (s.d 51.9 days) with a range of 1-114 days in length. Patients who survived had a mean length of hospital stay of 40 days (s.d 22.5) which, when compared, was much lower than the first- and second-year mortality cohorts. On the other hand, the one-year mortality cases had the longest length of hospital stays when compared to the second-year mortality and survivor groupings.

6.3.9 Mortality rate

The one-year mortality rate for this cohort of patients where survival status is known (n=116) was 9.5% (n=11), with 90.5% (n=105) of persons with tSCI still alive one year post-injury. An additional six patients passed away in their second year post-injury, resulting in a two-year mortality rate of 14.6%. Eighty-five per cent of patients (99/116; 85%) were still alive two years post-injury.

Table 6.1 Characteristics of the mortality and survivor group

	Mortality Group (First year) *n* = 11		**Mortality Group (Second year) *n* = 6**		**Survivor Group *n* = 99**	
Age (n; %)						
18-30	0	0	2	33.3	51	51.5
31-45	7	63.6	3	50	38	38.5
46-60	2	18.2	1	16.7	9	9.1
>61	2	18.2	0	0	1	1
Gender (n; %)						
Male	7	63.6	5	83.3	84	84.8
Female	4	36.4	1	16.7	15	15.2
Aetiology (n; %)						
Assault	3	27.3	2	33.3	69	69.7
Transport	3	27.3	2	33.3	24	24.2

Falls	4	36.4	1	16.7	5	5.1
Others	1	9.1	0	0	0	0
Missing	0	0	1	16.7	1	1
Spinal surgery (n; %)						
Yes	7	77.8	3	50	27	27.3
No	2	22.2	2	33.3	63	63.6
Missing	2	18.2	1	16.7	9	9.1
LOS (mean; s.d)	92.7	82.5	58	51.9	40.2	22.5
LOS (median; range)	81	19 - 267	46	4-144	35	9 -112
Time to surgery (mean; s.d)	6.8	5.2	14.6	8.5	10.8	9.4
Time to surgery (median; range)	6.5	1-14	18	5-21	8	0-31
Associated injuries (n; %)						
Yes	6	54.5	5	83.3	66	66.7
No	4	36.4	1	16.7	28	28.3
Missing	1	9.1	0	0	5	5.1
Secondary complication (n; %)						

Yes	7	63.6	1	16.7	26	26.3
No	2	18.2	3	50	50	50.5
Missing	2	18.2	2	33.3	23	23.2
ASIA classification (n; %)						
ASIA A	6	54.5	4	66.7	37	37.4
ASIA B	1	9.1	-	-	10	10.1
ASIA C	1	9.1	-	-	13	13.1
ASIA D	1	9.1	-	-	16	16.2
Missing	2	18.2	2	33.3	23	23.2

6.4 SENSITIVITY ANALYSIS OF KEY CANDIDATE EXPOSURES

To determine the sensitivity, specificity, positive predictive values (PPVs), negative predictive values (NPVs) and prevalence, the exposures below were cross-tabulated with vital status at one year. As seen in Table 6.2 below, all candidate exposures that were included have a relatively high positive predictive value, which means that these exposures, with some degree of accuracy, can determine whether patients will be alive one year post-injury. PPVs are positively correlated with prevalence (i.e., as prevalence increases/decreases, the positive predictive value moves in the same direction) compared to NPVs, which are negatively correlated with prevalence (i.e., as prevalence increases, negative predictive value goes down and vice versa) (Akobeng, 2007). In this instance, exposures with a prevalence of less than 10% was considered as being low. All selected candidate exposures had a relatively high prevalence, resulting in high positive predictive and low negative predictive values (Akobeng, 2007). Candidate exposures with the lowest prevalence were intermittent hospitalisation, secondary complications and surgical status. Although these exposures have low specificity and sensitivity due to low prevalence, they have an extremely high PPV which means they can still be used to determine the probability of survival one year post-injury accurately.

Table 6.2 Sensitivity, specificity, PPV and NPV of all candidate exposures aligned to the findings in the rapid review.

Exposures	Prevalence (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Age	100	100	n/a	91	n/a
Gender	100	100	n/a	91	n/a
Aetiology	98	100	n/a	91	n/a
Intermittent hospitalisation	47	49	46	94	11
Vertebral injury	77	83	11	91	6
Secondary complications	26	35	25	82	4
Associated injuries	65	71	33	92	9
Surgery	28	32	25	83	3
ASIA	73	100	n/a	91	n/a

PPV: Positive predictive value; NPV: Negative predictive value, n/a all participants had the candidate exposure of interest

Based on the sensitivity analysis performed above, Table 6.3 sought to describe these candidate exposures in detail as they relate to each mortality case within the first (*n*=11), and second-year mortality groups (*n*=6).

Table 6.3 Candidate exposure characteristics of individuals who have died within the first year and second year post- tSCI.

One year post-injury mortality cases										
Case	**Age**	**Gender**	**Aetiology**	**Intermittent hospitalisation[a]**	**Vertebral injury**	**Secondary complications**	**Associated injuries**	**Time to surgery (days)**	**ASIA**	**Days of survival**
Case 1	42	Female	Transport (Passenger)	Yes	T3 vertebral body fracture	1. Pressure ulcer 2. Lung embolism 3.Chronic renal disease	1. Mild TBI 2. Rib fractures 3. Bilateral lung contusions	11	A	316
Case 2	32	Male	Other (Hit by train)	Yes	L4/5 lamina and spinous process fracture and spondylolisthesis	1. Pressure ulcer	1. Degloving of lower back 2. 3rd and 4th rib fracture 3. Iliac wing fracture 4.L4/L5 haematoma	2	C	249
Case 3	54	Male	Assault (GSW)	No	C5-6 comminuted fracture C7-T1 spinous process fractures C6 burst fracture	1. Ventilator-acquired pneumonia (VAP)	1. Right-Haemothorax	14	A	85
Case 4	75	Male	Fall from height	No	Bifacet dislocation C5/6, C6 compression fracture	1. Atelectasis 2. Pulmonary oedema 3. VAP	N/A	4	A	187
Case 5	45	Female	Transport (Passenger)	Yes	C5 burst fracture; bilateral lamina fracture	n/a	1. Laceration to the scalp	9	D (CCS)	22
Case 6	49	Male	Assault (GSW)	Yes	T2 stable fracture-shattered vertebral body	n/a	1. Bilateral haemothoraces	n/a	A	197

							3rd and 4th rib fracture.			
Case 7	43	Female	Fall from height (Double bunk bed)	No	C3 Bifacet dislocation	1. UTI 2. Seizures	n/a	1	A	64
Case 8	36	Male	Fell from height (Tree)	Yes	T11-T12 fracture dislocation	1. Pressure ulcer 2. UTI	n/a	----	A	277
Case 9	38	Male	Transport (PVA)	Yes	C6/C7 bifacet fracture dislocation	----	*Missing*	----	----	233
Case 10	80	Female	Fall (Stairs)	No	C4 teardrop fracture, C4-C5, C5-C6 spinal stenosis	1. Anaemia	n/a	n/a	B (CCS)	218
Case 11	32	Male	Assault (Stabbing)	*Missing*	n/a	----	1. Bilateral haemopneumothoraces 2. Lung laceration 3. Small bowel injury -	n/a	----	
Second year post-injury mortality cases										
Case	**Age**	**Gender**	**Aetiology**	**Intermittent hospitalisation[a]**	**Vertebral injury**	**Secondary complications**	**Associated injuries**	**Time to surgery (days)**	**ASIA**	**Days of Survival**
Case 1	46	Male	Missing	No	C-spine C2-C4 body and lamina fracture C5 comminuted bilat lamina fracture and displacement	----	L-pneumothorax, axillary wall haemotoma, Fracture L-ulnar. Multiple rib facture ,axilla dislocation	----	----	416
Case 2	37	Female	Transport (Passenger)	Yes	T3-4 fracture dislocation	n/a	L-Radial shaft #, Bilat rib #	21	A	532

Case 3	39	Male	Transport (MVA)	Yes	T4, T5 lamina and transverse process fractures bilat; T6 pedicles, lamina, transverse and spinous pr	Klebsiella pneumonia	Right haemothorax; left pneumothorax, right clavicle fracture; bilat rib #; Gr3 liver injury; Gr1 Pancreatic injury, lung contusion	18	A	389
Case 4	42	Male	Fall (Fall from roof)	Yes	C6/7 Bifacet dislocation	n/a	n/a	5	A	627
Case 5	22	Male	Assault (GSW)	No	T4 Vertebral fracture	----	Left fibula fracture; R-Haemothorax; R-foot metatarsal 2nd, 3rd, 4th metatarsals	n/a	A	443
Case 6	21	Male	Assault (Stabbing)	Yes	Missing	n/a	Stab wounds: neck, right back and arm, left arm and flank; Right pneumothorax	n/a	----	447

[a] *Intermittent hospitalisation are instances where patients, who sustained a tSCI, were not transferred to a specialised centre but were first managed at a non-specialised care facility before being transferred to a specialised care facility (i.e., GSH)*

Not applicable (n/a): No secondary complications were reported during the patient's period of hospitalisation.; UTI: Urinary tract infection; PVA: Pedestrian vehicle accident; GSW: Gunshot wound; CCS: central cord syndrome; ---- Missing data

6.5 MATCHING OF ONE-YEAR MORTALITY CASES TO CONTROLS

As outlined in section 6.2, a gender and age matching method was used to match the one-year mortality cases to that of the survival group. Cases in the mortality group were randomly aligned to eleven cases who survived one year post-injury. The head-to-head matching of mortality to survival cases allowed the researcher to illustrate the difference in exposures between those who survived and those who did not. The eleven cases within the survival group were aligned according to the age category and gender of the mortality cases. During the matching process of the survival cases, one of the mortality cases (i.e., Case 10) could not be matched with a suitable case in the survival group as there were no patients who fell within this age category and gender membership. Patients were noted as having the exposure of interest if their clinical history aligned with the findings of the rapid review in Chapter 3. As is evident in Table 6.4, those patients who survived had a lower presence of exposures (Mean: 49%) than when compared to the mortality cases (Mean: 56%). For those cases where exposures were present, the variable was coded as red for that specific block. However, the variable was coded as green for those cases where exposures were not present. Cases with missing data related to certain variables were coded as yellow. As seen in Table 6.4, the majority of the one-year mortality cases who demised had the exposure of interest compared to the control cases where the exposure was not consistently present.

Table 6.4 A matched comparison of one-year mortality cases (n=11) to one-year survival cases (n=11)

		Cases (one-year mortality cases)													Controls (one-year survival cases)							
No.	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6	Exp 7	Exp 8	Exp 9			No.	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6	Exp 7	Exp 8	Exp 9	
1										67%		1										67%
2										67%		2										56%
3										67%		3										56%
4										88%		4										33%
5										44%		5										22%
6										44%		6										77%
7										56%		7										33%
8										56%		8										44%
9										44%		9										77%
10										44%		10	-	-	-	-	-	-	-	-	-	-
11										22%		11										22%
Mean: 56% (Excluding Case 10)												Mean: 49% (Excluding Case 10)										

Colour code: Red: exposure present; Green: exposure not present; Yellow: data regarding exposure is missing.

Exp 1: Age; Exp 2: Gender; Exp 3: Aetiology; Exp 4: Intermittent hospitalisation; Exp 5: Vertebral injury; Exp 6: Secondary complication; Exp 7: Associated injuries; Exp 8: Time to surgery, Exp 9: ASIA

Table 6.5 Variables discussed in each case of the eleven mortality cases listed in Table 6.3.

Case	Age	Location	BMI	Aetiology	Intermittent hospitalisation	Vertebral injuries	Secondary complications	Associated injuries	Time to surgery	Acute rehabilitation	ASIA admission	LOS
1	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	✓	-	-	✓	n/a	✓	✓	✓	✓	-	✓	✓
4	✓	-	✓	✓	n/a	✓	✓	n/a	✓	-	✓	✓
5	✓	-	-	✓	✓	✓	n/a	✓	✓	✓	✓	✓
6	✓	✓	-	✓	✓	✓	n/a	✓	n/a	-	✓	✓
7	✓	✓	-	✓	×	✓	✓	n/a	✓	-	✓	✓
8	✓	✓	-	✓	✓	✓	✓	n/a	×	-	✓	×
9	✓	✓	-	✓	✓	✓	×	×	×	-	×	×
10	✓	✓	✓	✓	×	✓	✓	n/a	n/a	-	✓	×
11	✓	-	-	✓	×	n/a	×	✓	n/a	-	×	×

n/a: not applicable; BMI: Body Mass Index; LOS: Length of stay; ×: No; ✓: Yes; -: Missing data

6.6 DESCRIPTIVE NARRATIVE OF ONE-YEAR MORTALITY CASES (n=11)

This section provides a narrative discussion related to the eleven mortality cases who demised within the first year post-injury. Variables discussed in each case have been tabulated in Table 6.5 above. These variables included patient age, aetiology; intermittent hospitalisation; vertebral injuries, secondary medical complications; associated injuries, time to surgery, acute rehabilitation, ASIA classification on admission and total length of hospital stay (LOS). Data regarding these variables were collected using the data collection instruments outlined in 4.5.1. Based on the domains of Krause's Theoretical Risk Model, additional variables such as place of residence and BMI were also captured as it is hypothesised these variables may influence may mortality. Variables related to injury factors (i.e., Krause's Theoretical Risk Model and Rapid Review) were coded as blue, while variables related to process measures (i.e., Donabedian's Model of Care and Rapid Review) were coded as red in the discussion sections of each case.

6.6.1 Case 1

The patient is a 42-year-old female from an urban/semi-urban suburb in the Cape Metropole who sustained a tSCI as a result of a transport-related aetiology. She was not directly transferred to a specialised level one trauma facility but was first admitted to a non-specialised district healthcare facility for management. One day post-injury, the patient was then referred from the non-specialised district healthcare facility to GSH spinal cord intensive care unit (ICU) (i.e., specialised healthcare facility). Upon examination at GSH, it was found that the patient sustained a T3 vertebral body fracture and was classified as an ASIA A. In addition to the above-mentioned vertebral injuries, the patient also sustained several associated injuries, which included a liver laceration, fracture of her left scapula, mild TBI, lung contusions, and bilateral rib fractures. On the eleventh day post-injury, the patient was scheduled for posterior thoracic fusion to stabilise the fracture site. During her period of hospitalisation, she developed sacral pressure, which was later confirmed to be infected with methicillin-resistant staphylococcus aureus and presented with a pulmonary embolism. In total, the patient was hospitalised for 267 days while receiving acute in-hospital rehabilitation for 259 days.

6.6.1.1 Discussion of case one

In this case, the patient was not transferred directly to a specialised level 1 trauma facility which may increase the patient's risk of neurological regression and development of secondary complications such as pressure ulcers (Consortium for Spinal Cord, 2008; Parent et al., 2011). She was also required to wait 11 days post-injury before receiving surgery, which has been shown to affect patient-specific outcomes such as function, and probability of survival if surgical intervention is provided later rather than earlier (Ahuja et al., 2020). The development of otherwise preventable secondary complications such as pressure ulcers may have also increased the patient's LOS, which is evident in this specific patient's case as she spent approximately 267 days in hospital. Longer hospital stays may have further increased this patient's probability of acquiring other infections or complications that may impact patient prognosis (Van Weert et al., 2014) and hamper participation in rehabilitation.

6.6.2 Case 2

The patient is a 32-year-old male who sustained a tSCI after being hit by a train. He weighed 44kg and was 1.63 meters in length, thus giving a BMI of 16.6 (i.e., underweight). Following his injury, he was directly transferred to GSH, where upon examination, it was found that the patient sustained spinal fractures to L4/5 lamina and spinous processes. In addition, he also presented with spondylolisthesis. Although he was transferred directly to GSH, he spent a total of eight days in high care before being admitted to the spinal ward. After undergoing a neurological examination, he was classified as an ASIA A. In addition to his spinal injuries, he also presented with degloving of the lower back, an iliac wing fracture, and a haematoma of L4/L5. Based on the patient's clinical status, it was decided by spinal consultants that the patient receive surgery, and a posterior lumbar fusion was performed two days post-injury. However, during his period of hospitalisation, he developed a sacral pressure ulcer. In total, the patient spent 81 days in hospital, while receiving acute in-hospital rehabilitation for 73 days.

6.6.2.1 Discussion of case two

In this specific case, this patient's surgical intervention was delayed by two days, which is a similar trend for other patients within the mortality cohort. It was not reported in the patient's medical folder whether he received surgical intervention for the iliac wing fracture. Hence, one would assume that this fracture was managed conservatively without any form of surgical intervention. Possible complications that may arise following this type of fracture is infection, neurovascular injury, bowel injury and malunion, which may result in deformity (Abrassart et al., 2009). In addition, he also developed a sacral pressure ulcer, which could have been linked to the delay in surgery (Balas et al., 2022). The reduced BMI may further increase the risk of developing pressure ulcers due to protrusion of bony prominences(Wen et al., 2022). As time to surgery increases, so does the patient's risk of developing secondary medical complications. Although the surgery was not performed within the first 24hrs (Ahuja et al., 2020), it took place much sooner than when compared to other cases within this grouping. Furthermore, due to multiple factors which may cause hospital-acquired pressure ulcers, delay in surgery time cannot be seen as the only one which may have affected this patient. Inappropriate turning schedules may also predispose patients to develop pressure ulcers. However the evidence regarding this intervention is relatively low (Gillespie et al., 2020).

6.6.3 Case 3

This case concerns a 54-year-old male who sustained a tSCI as a result of gunshot-related aetiology. There was no intermittent hospitalisation, and the patient was transferred directly to GSH for management. However, the patient was first admitted to the trauma unit, then moved to the respiratory ICU, and finally to the spinal ward for further management. On admission to GSH, the patient presented with comminuted fractures of C5-C6, spinous process fractures of C7-T1, and a burst fracture of C6. The only associated injury documented was a right pneumothorax. Following neurological assessment, he was classified as an ASIA A. Fourteen days post-injury, the patient underwent an anterior cervical decompression fusion (ACDF) and a posterior cervical fusion. During his period of hospitalisation, he developed ventilator-acquired pneumonia

(VAP) due to an acinetobacter infection. The patient eventually passed away after receiving care for 85 days

6.6.3.1 Discussion of case three

The patient presented with a low cervical spine injury, which has been proven to be an independent predictive factor for early mortality (Alimohammadi et al., 2020; Daneshvar et al., 2013). Furthermore, this patient had to wait 14 days post-injury to receive surgical intervention, which may have impacted this patient's prognosis (Ahuja et al., 2020). In addition to the above, the patient developed VAP, which further increases the risk of early mortality (Claridge et al., 2006), as pneumonia has been identified as a risk factor that may impact patient survival. However, as noted in other cases within the mortality group, infections such as these can be easily prevented. Considering the above, the patient's allostatic load may have been high, which could have made it hard for him to cope with the cumulative stresses placed on his body (Guidi et al., 2021).

6.6.4 Case 4

A 75-year-old male sustained a tSCI as a result of a fall from a height. He weighed approximately 86 kg and was 1.75 meters in length, thus giving a BMI of 28.1 (i.e., overweight). The patient was directly admitted to GSH high care, where he was then transferred to the spinal ICU. The transfer to the spinal ICU took place on the same day of admission to GSH. On examination, the patient presented with a C5/C6 bifacet dislocation and a compression fracture of C6. In addition to the spinal injury mentioned above, he also presented with several comorbidities: hypertension, cholesterol, and diabetes mellitus. It was decided that the patient would undergo surgery. However, he waited four days post-injury before undergoing an ACDF. During his period of hospitalisation, he developed pulmonary oedema, VAP, and atelectasis. In total, the patient's LOS at GSH was 103 days, after which he was then transferred to a private academic hospital for further management. However, the exact reason for being transferred to hospital was not documented.

6.6.4.1 Discussion of case four

This specific patient was a high-risk case based on his advanced age (Inglis et al., 2020), increased BMI (Wen et al., 2021), and pre-existing comorbidities (Inglis et al., 2020) he presented with on admission. Although surgical intervention was provided, the patient was required to wait four days before receiving spinal surgery. Once again, the delay in timely surgical intervention may have affected the patient's prognosis negatively as surgery was not provided in a timely manner (Ahuja et al., 2020). In addition to the patient's advanced age and presence of comorbidities, the development of secondary complications (Bokhari et al., 2019; Tee et al., 2013) during this patient's period of hospitalisation may have increased his probability of early mortality (Bokhari et al., 2019).

6.6.5 Case 5

In this case, a 45-year-old female who is RVD positive sustained a tSCI as a result of transport-related aetiology. Furthermore, she resided in an urban setting within the Cape

Metropole. Following her injury, the patient was first transferred to a non -specialised facility for management before being admitted to a specialised care facility. This period of intermediary hospitalisation was two days in length. Upon examination, it was found that the patient sustained a burst fracture of C5 and bilateral lamina fractures. The only reported associated injury was a laceration to the scalp. Only nine days post-injury did the patient undergo spinal surgery, which entailed the fusing of C5. In total, the patient spent only 18 days receiving acute in-hospital rehabilitation, while his total LOS was 19 days.

6.6.5.1 Discussion of case five

As noted in previous cases, this patient was not transferred directly to a specialised care facility for management (Consortium for Spinal Cord, 2008), which has been shown to improve outcomes such as mortality (Badhiwala et al., 2018). In addition, the patients time to surgery was also delayed as he only received surgical intervention nine days following his injury, which can impact the neurological recovery and overall prognosis (Ahuja et al., 2020). The relatively short LOS stay could be why this patient did not present with any secondary complications compared to patients with longer hospital stays (Gour-Provencal et al., 2021).

6.6.6 Case 6

A 49-year-old male from an urban/semi-urban suburb within the Cape Metropole sustained a tSCI as a result of gunshot-related aetiology. Following his injury, he was first transported to a non-specialised district healthcare facility. Thereafter, he was transferred to GSH. On admission to GSH, he presented with an ASIA A classification and a T2 vertebral body fracture and dislocation. He was first admitted to trauma and high care for acute management, then transferred to the D15 spinal ward for further management. The patient had no other pre-existing comorbidities besides being retroviral disease (RVD) positive. In addition to the above, the following concomitant injuries were noted on examination: bilateral haemothoraces and fractures of the third and fourth ribs. No secondary complications were reported during this participant's period of hospitalisation. In total, the participants' LOS was 30 days.

6.6.6.1 Discussion of case six

This patient was transferred to an intermediate healthcare facility instead of being transferred directly to a level one trauma facility (Consortium for Spinal Cord, 2008). He also sustained bilateral pneumothoraces and rib fractures, which may increase the probability of reduced survival if not managed timely and appropriately. In addition to the patient's concomitant injuries, he was also RVD positive; however, the exact CD4 count was not available as a direct measure of the immune response. Since the patient was RVD+, it increases his susceptibility to acquiring opportunistic infections (Mitiku et al., 2015), which may impact patient survival. As noted in the previous case, no secondary complications were reported and this may be due to a reduced LOS (Gour-Provencal et al., 2021).

6.6.7 Case 7

In this case, a 43-year-old female from an urban/semi-urban suburb in the Cape Metropole sustained a tSCI as a result of falling off a double bunk bed. She was admitted directly to GSH trauma, where she was transferred to C27 respiratory ICU and finally to C27 spinal ICU. On arrival at GSH she presented with a C3 bilateral facet dislocation and a deep vein thrombosis of the upper extremity. No associated injuries were noted in the patient's medical folder. Upon neurological examination, the patient was classified as ASIA A. It was then decided that the patient receive surgical intervention, and an ACDF was performed one day post-injury. In addition to the above spinal injuries, she developed a urinary tract infection (UTI) and seizures during her LOS. In total, the patient's LOS was 64 days.

6.6.7.1 Discussion of case seven

Although the patient was admitted directly to a level 1 trauma centre, she was first taken to the respiratory ICU before being admitted to the spinal ICU. This may have been due to limited space available in the spinal ICU. The presence of secondary complications during this patient's period of hospitalisation may have impacted her total LOS (Gour-Provencal et al., 2021). However, UTIs can easily be prevented if strict infection control measures are adhered to, and indwelling catheters do not remain inserted for prolonged periods of time (Salameh et al., 2015). Alternate methods, such as intermittent catheterisation, or using of condom catheters, may reduce this risk of bacteria growth in the urine (Kim et al., 2021). Although intermittent catheterisation poses a risk to infection, these infection rates are much lower than indwelling catheterisation (Kim et al., 2021).

6.6.8 Case 8

A 36-year-old male from an urban/semi-urban suburb sustained a tSCI after falling from a tree. The patient was initially admitted to a non-specialised secondary level healthcare facility, where he was then transferred to a non-specialised level one trauma facility and from the non-specialised level one trauma facility to GSH. The exact dates regarding transfer logistics between intermediate care facilities were not clear. On arrival, he presented with a vertebral fracture and dislocation of T11-T12 which was surgically managed. On the third day post-injury, the patient underwent spinal surgery for a posterior thoracolumbar fusion. During the patient's period of hospitalisation, he presented with a grade 3 pressure ulcer as well as a UTI.

6.6.8.1 Discussion of case eight

The patient was not immediately transferred to a level one trauma centre as per acute care guidelines. Furthermore, determining the dates regarding intermittent hospital proved to be somewhat challenging due to inadequate reporting of such information in the patient's medical folder (Marutha & Ngoepe, 2017). During the patient's period of hospitalisation, he also presented with pressure ulcers which may have been due to an inadequate turning schedule. Once again, the presence of UTIs may have been the result of prolonged use of an indwelling catheter which could have increased the patient's risk of developing a UTI (Kim et al., 2021). As indicated in the previous case, alternative methods which reduce the possibility of infection should be explored (Kim et al., 2021). However, infections such as UTIs are not usually fatal, but they may cause permanent damage to the urinary system if not managed appropriately (Moshi et al., 2021). This, in turn, may further increase the allostatic load placed on the patient's body.

6.6.9 Case 9

This case concerns a 38-year-old male from an urban/semi-urban suburb within the Cape Metropole. He sustained a tSCI as result of a transport-related aetiology, specifically a pedestrian accident. The patient was first transferred to a non-specialised district healthcare facility and subsequently transferred to a non-specialised level one trauma facility. At the non-specialised level one trauma facility a closed cervical reduction was attempted, however the closed reduction was not successful. Upon examination, the patient presented with a bifacet fracture dislocation of C6/C7 and an ASIA A classification on admission. The patient was then transferred to GSH to receive further surgical management. At GSH he received spinal surgery; however, the type of procedure and the date on which the procedure took place were not captured. However, data were missing regarding the development of secondary complications for this patient.

6.6.9.1 Discussion of case nine

As seen in the cases above, this patient was also transferred to an intermediary facility prior to receiving level one trauma care (Parent et al., 2011). The patient was first managed conservatively at a non-specialised healthcare facility; however, the cervical reduction was unsuccessful, resulting in the patient being transferred to a specialised healthcare facility for further care. The reason for the failed reduction may be due to the lack of training and experience in managing patients with SCI using this sort of intervention (Workman & Kruger, 2019). Furthermore, techniques such as cervical reduction, which are not performed correctly, may negatively impact a patient's prognosis, and increase their LOS.

6.6.10 Case 10

In this case, an 80-year female from an urban suburb within the Cape Metropole with a history of hypertension sustained a tSCI after falling down a flight of stairs. She weighed approximately 65kg and was 1.63 meters in length, thus giving a BMI of 24.5. (i.e., normal). The patient was admitted directly to GSH with no intermediate hospitalisation taking place. Upon examination, the patient presented with a C4 teardrop fracture with spinal stenosis from C4 – C6. The spine injuries and spinal stenosis resulted in a central cord syndrome (CCS), and the patient was subsequently classified as an ASIA B. At a five-month follow-up, the patient presented with neuropathic pain and bladder and bowel dysfunction. Remarkedly, the patient did not present with any secondary complications besides anaemia.

6.6.10.1 Discussion of case ten

Taking into account the patient's advanced age (Furlan & Fehlings, 2009), history of hypertension (Varma et al., 2010), level of injury (low cervical spine injury) (Claridge et al., 2006), and spinal stenosis, it places her within the high-risk grouping with respect to early mortality. The positive that can be taken from this case is that the patient did not develop any secondary complications during her period of hospitalisation (Dorner et al., 2019). Furthermore, complications, such as neuropathic pain and bladder and bowel dysfunction, may have further impacted the patients' health post-discharge (Madasa et al., 2020).

6.6.11 Case 11

This case concerns a 32-year-old male who sustained a tSCI as a result of assault-related aetiology, specifically stabbing. The acute spinal care unit saw the patient, however, admission dates to GSH are missing, which makes it challenging to determine if and for how long the patient was admitted to intermediate care. On examination, the patient sustained bilateral haemopneumothoraces, lung laceration, and a small bowel injury.

6.6.11.1 Discussion of case eleven

Due to the limited data available on this patient, it was impossible to highlight the factors that may have negatively impacted this patient care pathway.

6.7 CANDIDATE EXPOSURES IMPACTING EARLY MORTALITY

A concept map (see Figure 6.1) was used to illustrate the linkage between the candidate exposures highlighted in chapter 3. Furthermore, it allowed a visual representation of how each exposure from the cases discussed in section 6.5 may have directly, or indirectly impacted the early mortality of these patients. As seen in Figure 6.1, the patients age at the onset of injury is directly related to mortality, while inappropriate transfer logistics/

intermittent hospitalisation would been seen as indirectly affecting mortality. These factors are also at times interrelated. For example, intermittent hospitalisations may predispose patients to secondary medical complications which are in turn linked to early mortality in persons who have sustained tSCI.

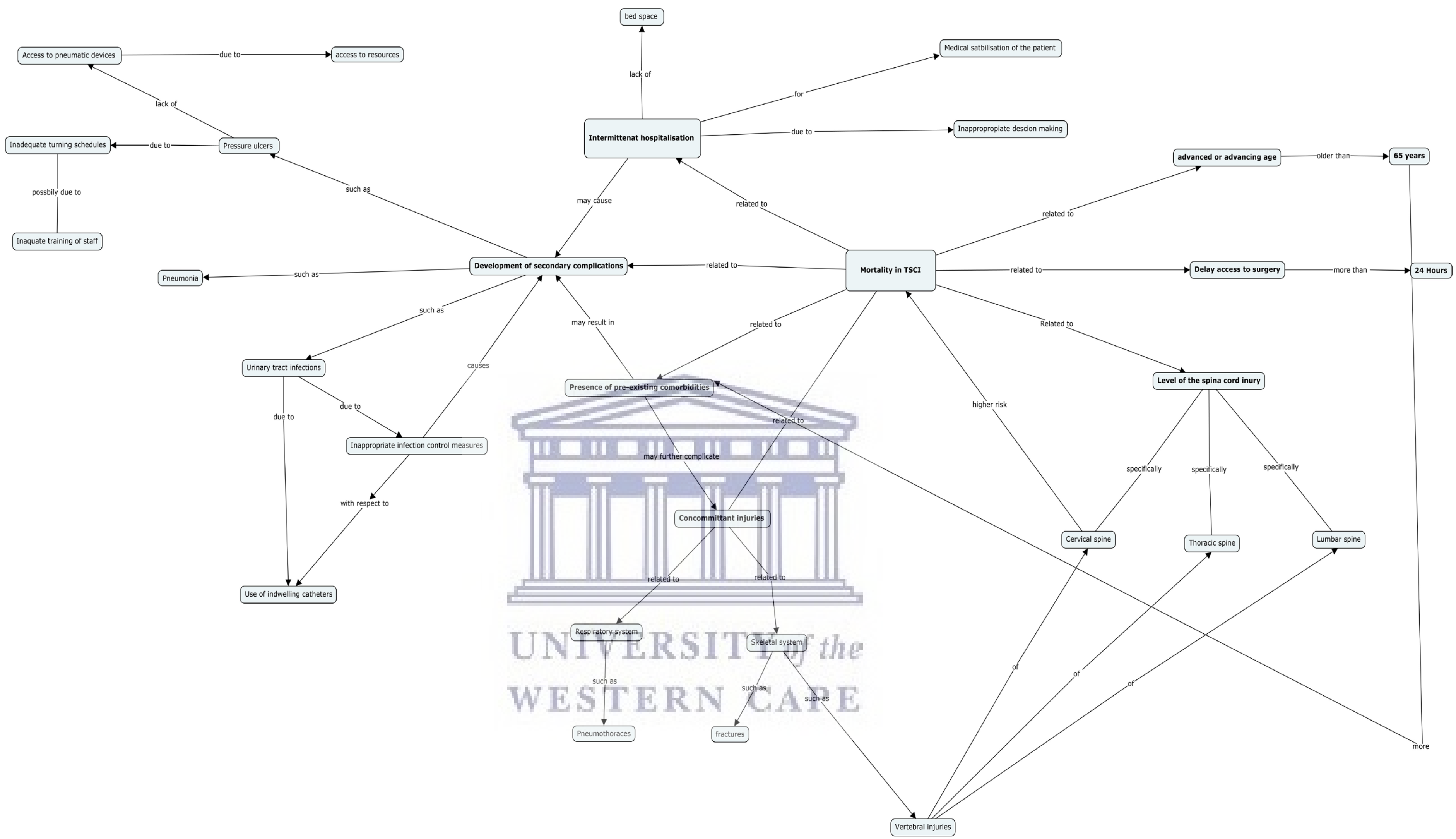


Figure 6.1 Concept map: Candidate exposures impacting early mortality

6.8 CONCLUSION

Process factors, according to the operationalisation of Donabedian's model of quality medical care and as found in the rapid review (Chapter 3), identified transfer logistics, adequate documentation in medical records, time to spinal surgical intervention and presence of secondary medical complications to be factors that may have influenced early mortality in the above cases. Transfer logistics were not routinely present in the medical folder, which did not allow one to determine time-sensitive measures from the accident site to the level one trauma centre.

Furthermore, patients were not always transferred directly to a level one trauma facility. Inadequate transfer logistics such as these may further impact a patient's probability of survival. Most of the mortality cases had not received surgery in a timely manner, with only one patient receiving surgery one day post-injury. In addition to the above, a large proportion of cases developed secondary complications during their period of hospitalisation. These complications are modifiable and can be prevented by screening and maintaining strict infection control measures, or in the case of pressure ulcers, regular turning schedules and pneumatic mattresses. In addition, if complications directly affecting the respiratory system are not managed timeously and effectively, it may result in early death.

As per Krause's model, risk factors for mortality revealed in these one-year cases that the presence of secondary complications coupled with advanced age or comorbidities might further increase the probability of reduced survival.

Based on the sensitivity analysis in Table 6.1, it is evident that these candidate exposures have a high probability of determining the vital status of persons with SCI at one year.

CHAPTER SEVEN

DISCUSSION

7.1 INTRODUCTION

This chapter will provide an integrated discussion of this study's main results related to Chapter 3 (i.e., rapid review), Chapter 5 (i.e., descriptive results on the cohort's characteristics and exposures) and Chapter 6 (i.e., survival model). In addition, this chapter also seeks to integrate the results from this study to those of existing literature to determine whether any similarities or differences exist between this study's results and other previously published research. Furthermore, this chapter will discuss the methodological considerations which may have impacted the ecological validity of the study findings (i.e., internal and external validity). Krause's theoretical risk model and Donabedian's model of care were used to outline this discussion chapter.

7.2 EPIDEMIOLOGY

The epidemiological aspects that were investigated in this thesis included age and gender. In relation to demographical factors, male participants in the age category of 18 -30 years formed the largest proportion of persons who sustained traumatic spinal cord injuries (tSCIs) than when compared to their female counterparts, and is consistent with findings in the local (Joseph et al., 2015; Sothmann et al., 2015) and international literature (Golestani et al., 2022; Rahimi-Movaghar et al., 2013). This holds true with respect to the one- and two-year mortality groups where males also formed the largest percentage. The results of this study were further corroborated by Rahimi-Movaghar et al. (2013), who found that males made up the largest percentage of persons who sustained a tSCI within developing countries (Rahimi-Movaghar et al., 2013). In contrast, While the mean age from the pooled studies in the review by Rahimi-Movaghar et al. (2013) was 32.4 years. This result was similar to the current study's findings, which found the age of injury onset to be 33.5 years in this specific cohort of participants. The noticeable gender difference is because males within the age category of 15 -35 years usually engage in riskier behaviour (Tamás et al., 2019) than when compared to their female counterparts and may therefore increase their likelihood of sustaining a spinal cord injury (SCI). Considering the roles that males play within various cultural settings, sustaining an SCI may impact their ability to earn an income (Popowich Sheldon et al., 2011). Considering these results, preventative measures in South Africa should target males within the age category of 18-30 years who are at a higher risk of sustaining SCI as a result of assault and transport-related aetiology.

Contrary to the findings of this study which found assault to be the main cause of tSCI, the reviews by Rahimi-Movaghar et al. (2013) and Golestani et al. (2022) found that motor vehicle accidents were the main cause of tSCIs in developing countries, which was followed by fall-related aetiologies. The difference in aetiology in relation to this study's findings and other literature could be due to the high rate of crime and violence in South Africa compared to other developing (Harris & Vermaak, 2015) and developed countries. Löfvenmark et al. (2015) also found assault to be one of Botswana's most common causes of tSCI; however, it was only second to transport-related aetiologies. According to the review by Chiu et al. (2010) and the study by Moshi et al. (2017), the leading cause of tSCI were falls which was only the third highest cause of tSCI in this specific study. In more developed countries, motor vehicle accidents were also the most common cause (Singh et al., 2014). The results regarding the causes of tSCI from this study are similar to the results of a previous study conducted in the same geographical area (Joseph et al., 2015). Based on the results of the current study and those by (Joseph et al., 2015), not much has changed in the epidemiological profile of tSCI in the Cape Metropolitan region in relation to the secondary medical complication rate and aetiology. This is disturbing considering the burden SCI places on the healthcare system (Miseer et al., 2019).

Results from the current study found that incomplete spinal lesions (52%, 67/129) were slightly more prevalent than when compared to complete spinal lesions (48%, 62/129).This was contrary to the results by Rahimi-Movaghar et al. (2013), who found that complete SCIs were more common in developing countries than incomplete spinal lesions. Although this is the case, Rahimi-Movaghar et al. (2013), Golestani et al. (2022) found no difference in relation to the completeness (i.e., complete vs incomplete) of injury after pooling data related to the severity of the injury. This finding in the current study could be attributed to the high volume of assault cases which consisted of stabbing-related aetiologies. As shown in the current study's results, 35% of assault cases were due to stabbing-related aetiology. This form of aetiology is linked to a higher likelihood of incomplete spinal lesions (Peacock & Key, 1977; Takemura et al., 2006).

Regarding the level of injury, of 119 participants who have data relating to the level of injury, 60% (72/119) were characterised as paraplegics and 40% (47/119) as tetraplegics. Literature has shown that patients who were classified as paraplegics on admission were more common than those patients who were classified as tetraplegics (Golestani et al., 2022; Rahimi-Movaghar et al., 2013). This is important as patients with paraplegia have been found to have a greater probability of returning to work than patients with tetraplegia (Anderson et al., 2007; Krause, 1992). Meaning, these individuals can still contribute to the economy in a meaningful way and support their families.

7.3 INJURY CHARACTERISTICS AS PER KRAUSE'S THEORETICAL RISK MODEL

7.3.1 Severity of injury (i.e., complete or incomplete)

Another factor related to injury characteristics was the completeness of injury, which also contributes to the severity of injury. Based on the results of this study, 60% (6/10) and 50% (5/10) of participants who demised within the first- and second year post-injury were classified as having a complete spinal lesion (i.e., ASIA A). This was in line with results from the rapid review (See Chapter 3), which found that patients who were classified as an ASIA A (i.e., complete lesion) are at an increased risk of early mortality than patients who were classified as an ASIA B, C or D (i.e., incomplete lesion) (Daneshvar et al., 2013; Neumann et al., 2009). Completeness of the spinal injury seems to play an integral part in early mortality as patients who have complete lesions have impaired sensation and motor function which may increase their risk of developing secondary medical complications such as pressure ulcers and respiratory complications which are linked to early mortality (Joseph & Wikmar, 2016).

Regarding the level of injury, four participants within the one-year mortality sustained SCI to the cervical spine. Of these, three were high-level lesions (i.e., C3, C3 and C4) and one was low-level (C5). Once again, these results were consistent with the findings from the rapid review in which Claxton et al. (1998) and Daneshvar et al. (2013) found that patients with SCI at the level of C4 were at a higher risk or early mortality. This is because patients with higher-level spinal lesions are at a higher risk of developing respiratory complications owing to impaired function of the diaphragm, which may predispose them to respiratory failure (Shao et al., 2011). Possible interventions, as identified in the literature, relate to respiratory muscle training, which seeks to improve the strength of the muscles required for breathing (Berlowitz et al., 2016; Brown et al., 2006; Consortium for Spinal Cord, 2008). Another intervention used is abdominal binding. This intervention seeks to decrease abdominal compliance, thus allowing the diaphragm to revert to its normal resting position (Berlowitz et al., 2016). Abdominal binding also assists in restoring pressure across the thorax and abdomen (Berlowitz et al., 2016). The above interventions are relatively inexpensive and may reduce the risk of patients developing pneumonia. Measures that can prevent respiratory infection, such as ventilator-acquired pneumonia, should include the routine disinfection of ventilators (Abbasi & Korooni, 2018). In addition, deep breathing exercises and mobilisation should also be encouraged to prevent the occurrence of post operative pneumonia (Burns, 2007). Based on the above, there is no reason for these interventions not to be used routinely at the point of care. Especially in the cases where patients present with dysfunction of the diaphragm or as a prophylactic measure to prevent respiratory infection. Additionally, they are cost-effective to use in a resource constraint environment such as South Africa. Therefore, identifying a patient's baseline injury characteristics is fundamental in determining their risk of early mortality and ascertaining which strategies should be employed to prevent secondary medical complications.

7.3.2 Secondary medical complications

This study's prevalence of secondary medical complications during acute care is directly comparable to a previous study (Joseph et al., 2015). In relation to the occurrence of secondary medical complications during acute care hospitalisation, pressure ulcers (17/125, 14%), pneumonia (15/125, 12%), neuropathic pain (14/125, 11%) and UTIs (6/125, 4.8%) were the four most prevalent secondary complications. These findings were consistent with those identified in the rapid review that found infections and pneumonia to be the most prevalent secondary complications impacting mortality. They were also in line with the results of Joseph and Wikmar (2016) and Wahman et al. (2019) who found pressure ulcers, pulmonary complications, UTIs and neuropathic pain to be the most prevalent secondary medical complications during acute care. In the group which underwent surgery, the four most prevalent complications were neuropathic pain (7/43, 16%), pressure ulcers (7/43, 16%), pneumonia (7/43, 16%), and UTIs (3/43, 7%). The rapid review did not find any evidence which support these results. Although this is the case, the study by Bourassa-Moreau et al. (2013) found similar results in relation to the current study with respect to persons with tSCI who underwent surgery. Secondary medical complications related to the one-year mortality cohort consisted mainly of pressure ulcers, respiratory complications (pneumonia, lung embolism, atelectasis and pulmonary oedema) and UTIs. As found in the literature, it is well documented that the presence of secondary complications related to respiratory dysfunction (Brown et al., 2006), pressure ulcers (Shiferaw et al., 2020; Zakrasek et al., 2015) and UTIs (Kim et al., 2021) increase the risk of early mortality in persons following the onset of a tSCI.

The aforementioned complications can be modified, meaning, measures can be put in place to reduce their occurrence when compared to non-modifiable factors such as age and gender, which cannot be changed. If these complications are not managed adequately, they will impact the survival of these patients and increase the burden of care on the health system used (White et al., 2017). This is especially true for patients who develop pressure ulcers and are required to spend prolonged periods of time in the hospital for treatment (Shiferaw et al., 2020). Furthermore, participants who developed pressure ulcers, infection, pneumonia and UTIs in the current study also spent, on average, a longer in hospital receiving care. This increased length of hospital stays and the presence of secondary medical complications may result in financial implications for the facilities providing the care and for the patients seeking care (Malekzadeh et al., 2022; Merritt et al., 2019). Based on the above, it can be stated that the presence of secondary medical complications can further complicate the care continuum of persons with tSCI if they are not managed appropriately and in a timely manner. Although a significant proportion of patients still presented with secondary complications in this specific cohort, the overall presence of secondary complications such as pressure ulcers, pneumonia and

UTI were much lower as compared to a previous study at the same facility (Conradsson et al., 2019). This reduction in prevalence of secondary medical complications in the current study could be as a result of improved secondary health prevention programmes, or infection control measures. Conradsson et al. (2019) found the high prevalence of secondary complications such as pressure ulcers to be disturbing specifically because specialised care services seek to reduce the occurrence of such complications. Prevention strategies to reduce the occurrence of secondary complications should commence as soon as possible to reduce the impact of these complications on the patient prognosis and quality of life. For example, rehabilitation should be commenced as early as possible to encourage patients to be more responsible for their own health and to educate patients on self-management strategies to prevent the occurrence of secondary complications. This may involve the use of mobile applications (Mortenson et al., 2018) or structured self-management programmes (Meade et al., 2016). In addition, they should also be encouraged to employ a more active approach in the prevention programmes (Conradsson et al., 2019), which may be facilitated by encouraging early mobilisation and independency within the patient's limitations due reduce secondary complication rates(Epstein, 2014).

7.4 PROCESS MEASURES AS PER DONABEDIAN'S MODEL OF CARE

7.4.1 Time to surgery

Time-sensitive measures such as time to surgery were not in line with the findings of acute care guidelines (Consortium for Spinal Cord, 2008; Fehlings et al., 2011) in managing persons who sustained tSCI. Findings in relation to spinal surgery found the mean time to surgery to be 11 days (s.d 9.6 days). Of the 45 participants who underwent surgery, 82% (37/45) experienced a delayed time to spinal surgery (i.e.,>3 days) while the mean time to surgery in the one-year and two-year mortality cohorts were 6.8 and 14.6 days, respectively. Aetiologies which accounted for the highest number of surgery-related cases were transport and fall related. This finding is due to the fact that patients with transport- and fall-related aetiologies are usually associated with polytraumas and therefore may require management for other associated injuries prior to undergoing spinal surgery (Kanna et al., 2021), thus causing a delay in time to spinal surgery. This trend of delayed spinal surgical intervention following a SCI was in line with literature from other developing countries, such as Botswana which reported a median time to spinal surgery of 11 days following spinal trauma (Löfvenmark et al., 2015). While other studies by Magogo et al. (2021) and Leidel et al. (2005), found the median and mean time to surgical intervention to be 23 and 33.2 days, respectively. Findings, such as those in Tanzania, provide a greater argument for the implications of delayed time to spinal surgery and its impact on patient prognosis, as patients may be negatively impacted by something seen to be modifiable. It has also been proven that the timing of spinal surgery directly impacts the rate of secondary medical complications (Bourassa-Moreau et al., 2013). As noted in the current study, 77% of participants who underwent spinal surgery > 3 days developed secondary complications compared to 23%, where spinal surgery was performed within three days. Although surgery was eventually provided to patients who needed it, this was not in line with best practice guidelines that advocate spinal decompression being performed within the first 24 hours following an SCI (Glennie et al., 2017). This may currently not be achievable owing to the many challenges faced by the South African public healthcare system (Coovadia et al., 2009), even though it has been proven that patients who undergo early spinal decompression surgery (i.e., within the first 24 hrs.) present with an improvement in neurological function post-surgery (Ahuja et al., 2020). A noticeable finding though was that participants who did not undergo surgery had a higher chance of survival. This could be attributed to the fact that patients receiving delayed spinal surgery have an increased risk of developing secondary complications as well as experiencing an increased length of hospital stay (Mckinley et al., 2004) Alternatively, it could be because surgery is only recommended, reserved, for those with major spinal instability, bony fragments in the spinal canal and complex associated injuries. All of which may increase their likelihood of early mortality. It is therefore recommended to audit the criteria used to determine those who undergo spinal surgery.

7.4.2 Medical management

In relation to the mortality cohorts, two of the mortality cases in the one-year mortality grouping underwent failed cervical reductions. Although the failed reductions related to the mortality cases (see Chapter 6) may not have contributed directly to mortality, they may increase a patient's length of hospital stay, which has been proven to impact the occurrence of hospital-acquired infections or secondary complications (Rojas-García et al., 2018; Siddique et al., 2021). These patients may then need to be transferred from non-specialised facilities to specialised ones, further increasing the length of hospital stay and time to management. A recent paper highlighted that persons who have sustained tSCI are usually managed by specialist orthopaedic and neurosurgeons who are not always confident in performing these procedures (Workman & Kruger, 2019). According to the study by Workman and Kruger (2019), 21% of the specialists surveyed had indicated that they did not receive any formal training in cervical reduction at a postgraduate level, while only 2% of participants indicated that they received training at an undergraduate level. Hence, the results from this survey highlight the need for training in cervical reduction for expert and novice clinicians, which could directly impact patient outcomes and length of hospital stay. Currently, there is no prerequisite training for emergency care clinicians regarding the management of tSCIs. Hence, they are required to have advanced trauma life support (ATLS); however, this does not include training in cervical reduction (American College of Surgeons, 2018; International Advanced Trauma Life Support Working Group, 2013; Schmidt et al., 2009). If clinicians are upskilled at every level of care, patients can then be managed at a district level, and referred to a tertiary level when it is safe to do so, which would, in turn, lighten the load on already overburdened trauma facilities. There is an obligation to ensure all medical practitioners are adequately trained to perform cervical reductions to ensure patient prognosis is not negatively impacted taking into account the constitutional court ruling requiring cervical reductions to be performed within at least 4 hours (Mohideen et al., 2019). However, this may not be practically possible in a resource constraint environment (Mohideen et al., 2019). Furthermore, the lack of exposure of clinicians to spinal injuries that require cervical reduction may pose a further challenge in obtaining an adequate level of skill and expertise among medical practitioners. Therefore, there is a need to strengthen expertise through continuous professional development courses, aiming to embed these competencies into medical practitioners undergraduate and postgraduate medical training. Owing to the high incidence of SCI in the Cape Metropolitan region optimising the chances of survival and functioning of patients in the prime of their lives is fundamental. In addition, it can also assist in reducing the direct healthcare costs as result of sustaining a SCI. The direct costs of healthcare for persons in developed countries are relatively higher than when compared to developing countries (Malekzadeh et al., 2022). This could be explained by the higher cost of pharmaceuticals and workforce in these developed countries. According to a systematic review by Malekzadeh et al. (2022) the mean cost of acute care persons with SCIs range from $290 to $612 510.

7.4.3 Inappropriate transfer logistics

Indirect transfer to intermediary care facilities was also common amongst the entire cohort. It was also common amongst those patients who demised within the first and second year post-onset of injury. Participants' mean time to acute care from admission to intermediate facilities was 3.25 days (s.d 6.2). With transport and assault-related aetiologies accounting for the largest number of intermittent hospitalisations. This is not in line with acute management guidelines, which suggest that persons with a tSCI be immediately transferred to a level one trauma centre. Literature has proven that patients who sustained a traumatic event, such as an SCI, and not transferred directly to a level one trauma centre, may experience poorer outcomes/ prognosis (Yohann et al., 2022; Yohann et al., 2021). A recent systematic by Yohann et al. (2021) review assessed the effect of transfer status on trauma outcomes in low- and middle-income countries. Their findings showed that patients who were indirectly transferred experienced longer periods of hospitalisations and took longer to arrive at referral hospitals after their injuries compared to those who were transferred directly. Reasons for indirect transfer within the South African context could be related to specialised care services being predominantly centralised within the urban hubs. Hence, those who reside in semi-urban and rural areas are first transferred to district or community health centres prior to being transferred to level one trauma centres (Kong et al., 2019; Senekal & Vincent-Lambert, 2021).

A primary healthcare approach (PHC) is being employed within South Africa, which merely seeks to provide equitable care to patients seeking medical attention (Dookie & Singh, 2012; Keleher, 2001). At this stage, patients who are not transferred to specialised SCI services are not receiving the same care as those who are recipients of specialised care, which technically means it is not in line with a PHC healthcare approach. Furthermore, due to the long distances these patients are required to travel, the critical period in which surgeries can be performed is missed and may negatively impact the patient's diagnosis (Ahuja et al., 2020) and may lead to morbidity and death in extreme cases. The results from the current study support those by Yohann et al. (2021), 52% (n=29) of patients, who were admitted at intermediary facilities for management, spent > 36 days in the hospital compared to 48% (n=27) who were admitted directly to the specialised level one trauma care. Another study by Yohann et al. (2022) found that those patients who were not transported directly to a level 1 trauma centre doubled their mortality risk compared to those who transferred directly. These findings by Yohann et al. (2022) once again supported those of the current study, which found that 6 out of the 11 cases who demised within the first year post-injury received intermediary care at non-specialised facilities. In addition, 67% (4/6) who demised within the second-year post-injury received intermediate hospital. Considering the country's history with respect to access to healthcare services and differences between urban and rural settings, one may find it challenging to standardise care with respect to access to level one trauma centres and spinal surgery.

Therefore, ways in which to improve access to these services should be explored further, such as the decentralisation of trauma care services for tSCI management. If a clear pathway exists with respect to how a decentralised trauma network (Ernstberger et al., 2018) should be established, we could then determine what is needed in terms of resources and personnel to provide timely care. In addition, the National Health Insurance (NHI) scheme may assist in reducing the degree of inequality in relation to access to specialist services for persons with a tSCI. This may be a viable option as the main objective of the NHI is to provide access to quality healthcare services for everyone residing in South Africa (Naidoo, 2012). One way to achieve this is to create specialist district clinical support teams (Naidoo, 2012) at a district level that can better manage traumatic injuries at a district level. This can reduce the load being placed on tertiary/specialised healthcare facilities.

7.4.4 Time to rehabilitation

Regarding time to acute in-hospital rehabilitation (i.e., time to referral since admission to hospital), the mean time to rehabilitation was 3.25 days (s.d 5.2). Fifty-three per cent of participants who sustained their injuries as a result of transport-related aetiology were referred to acute in-hospital rehabilitation within one day. This was then followed by assault. In addition, a statistically significant association was noted between time to in-hospital rehabilitation and the mechanism of injury. The median time from onset of injury to admission to acute inpatient rehabilitation was six days for participants included in this specific cohort, meaning that a large proportion of patients included in this cohort received inpatient rehabilitation within one week of being admitted to the Groote Schuur Hospital (GSH) ASCI unit. This is significant as it has been established that early referral to rehabilitation is beneficial for the patients and can be seen as a strong predictor for functional outcome within the first few weeks following a spinal cord injury (Scivoletto et al., 2005; Sumida et al., 2001). These improvements in functional outcomes thus translate to an improved ability of patients to perform their activities of daily life. A significant difference can be noted with respect to motor scores and sensory scores on admission and discharge. Whether these changes can be attributed to timely access to specialised care, including inpatient rehabilitation, is debatable as these changes may result from natural recovery. Natural recovery relates to the conversion of a patient's neurological status from complete (ASIA A) to incomplete (ASIA B, C, D) and vice versa (Kirshblum et al., 2021; Scivoletto et al., 2005). As found in the review by Kirshblum et al. (2021), natural recovery occurs most rapidly within the first three months following injury and plateaus at 12- 18 months. Therefore, some of the early changes seen in relation to motor recovery can result from normal progress. Determining whether changes occur as a result of natural recovery (i.e., the normal healing process) or acute rehabilitation (i.e., intervention to improve patient functional outcomes) would not be possible owing to obvious ethical implications (i.e., withholding treatment that may \potentially improve patient prognosis). Although this is the case, acute in-hospital rehabilitation that incorporates low-intensity rehabilitation within the first four days post-injury has been shown to improve motor recovery (Lewis et al., 2022). In addition to this, rehabilitation can be used as a means to promote patient well-being by utilising educational, vocational and peer support interventions (Simpson et al., 2022). These, in turn directly, impact the patients' quality of life. Due to the fact that all persons who sustained a tSCI might not be in the position to receive daily intensive rehabilitation, the use of telerehabilitation services should be explored owing to the potential benefit it may have for these patients (Solomon et al., 2022). Some of these potential benefits are related to the reduction in depression and feelings of self-isolation (Solomon et al., 2022). In addition, it may reduce secondary complications by utilising self-management strategies (Solomon et al., 2022). Regarding acute in-hospital rehabilitation, the average length of stay of acute in-hospital rehabilitation was 35 days. This ranged from 0 to 259 days with an s.d of 33.5 days. Although studies have assessed the influence of various rehabilitation interventions on the SCI population (Burns, Marino, et al., 2017), none have really assessed the length of rehabilitation received when admitted for care at the hospital. Most studies assessed the length of rehabilitation once admitted to rehabilitation facilities. Assault-related aetiologies had a higher percentage of patients who spent longer acute inpatient rehabilitation stays. This was followed by transport and fall-related aetiology, respectively A statistically significant association was found between total length of acute in-hospital rehabilitation and stabbing status (yes/no), MVA status (yes/no) and PVA status (yes/no).

7.4.5 Length of hospital stay

Overall, this study's participants spent on average 42.6 days receiving care which was longer than what is reported in the international literature (Burns, Santos, et al., 2017). According to the literature review by Burns, Santos, et al. (2017), the total length of acute hospital stays ranged from 28 -37.8 days in length. Based on what was reported by Burns, Santos, et al. (2017), this study's current length of hospital stay is much higher than international standards. Regarding the total length of hospital, surgery status, ASIA A classification and tetraplegia were all found to be predictors of an increased length of hospital. These findings were consistent with those of Dvorak et al. (2015), who found that patients who received spinal surgery earlier (i.e., with 24hrs) experienced a reduced length of hospital stay than when compared to patients who received surgery later than 24 hours.

Timing of surgery also translated to improved functional outcomes with respect to those who received surgery in a timely manner. This supported the current study's results, which found that post-surgery, the percentage of complete spinal lesions dropped to 49% (n=22) and the percentage of incomplete lesions increased to 44% (n=20). Patients who are classified with complete spinal cord lesions require more care and usually present with more secondary complications, which increase their likelihood of increased length of hospital stay. This was proven by the study by Conradsson et al. (2019), in which the risk factors related to acute hospitalisation were evaluated. Corroborating the findings of the current study regarding the influence of the level of injury (i.e., paraplegia/tetraplegia) on length of hospital stay were those by Tooth et al. (2003), Eastwood et al. (1999) and (Richard-Denis et al., 2018). All the studies mentioned above found that patients who presented with tetraplegia had an increased acute length of hospital stay. This could be explained by the fact that patients who are classified as tetraplegics also require more intensive care due to their increased risk of developing secondary medical complications (Joseph & Wikmar, 2016; Richard-Denis et al., 2018), which explains the reason why these patients are hospitalised for prolonged periods of time.

7.5 DESCRIPTIVE MORTALITY MODEL

The main findings of the survival model related to associated/vertebral injuries (Chhabra et al., 2022), pre-existing comorbidities (Blex et al., 2022), inadequate transfer logistics (Yohann et al., 2022; Yohann et al., 2021), development of secondary complications during the participants' period of hospitalisation (Tee et al., 2013), delayed time to spinal surgery (Yousefifard et al., 2017), and total length of hospital stay (Blex et al., 2022). Most of the secondary medical complications that developed during the participants' length of hospital stay were modifiable and could thus have been prevented. Results from the rapid review found the presence of secondary medical complications to be an independent predictor of early mortality, which should be further tested during the validation stage of the model development process.

Six of the 11 one-year mortality cases and five of the six second-year mortality cases presented with associated injuries on arrival to acute care. Patients who present with multiple associated injuries will usually have higher ISSs on admission. The use of this scoring system was found to be a consistent independent predictor of early mortality with respect to the results of the rapid review (Divanoglou et al., 2010).

The presence of pre-existing comorbidities was not well documented in the one- and two-year mortality cases. However, one case in the one-year mortality who demised was RVD positive, while a second case presented with hypertension, increased BMI, cholesterol, and diabetes mellitus. Although not well documented, the results from the rapid review clearly show that the presence of pre-existing conditions negatively impacts a patient's short-term patient survival (Blex et al., 2022). This holds true for those patients who have been selected to undergo surgery (Mcgee et al., 2022). Furthermore, the use of the CCI is a useful tool in the risk stratification of early mortality.

Six out of the 11 one-year and four out of the six second-year mortality cases experienced intermittent hospitalisation. Patients who received intermittent hospitalisation due to inappropriate decision making, or lack of bed space, are also at a higher risk of developing secondary medical complications which may be due to poor infection control measures or lack of access to resources. For example, access to pneumatic mattresses to prevent pressure ulcer and routine disinfection of ventilators (Divanoglou et al., 2010).

Three out of the five one-year mortality cases who presented with secondary complications experienced delayed surgery (≥ 3 days). In relation to the second-year mortality, three out of three second-year mortality cases who developed secondary complications underwent delayed surgery. Delayed spinal surgery may increase the risk of developing secondary complications, such as pressure ulcers, as patients must remain immobile while waiting for surgical intervention (Joseph & Wikmar, 2016). Lack of adequate turning surgical schedules and inadequate training of staff may further exacerbate this problem.

The length of hospital stay was also an important factor which was influenced by the presence of secondary medical complications. Five out of five of the one-year mortality cases who had increased length of hospital stay (≥ 36 days) developed secondary complications during their hospital stay. The prevalence in the second-year mortality cases was lower with only one participant presenting with a secondary complication. However, the length of hospital stay for this one patient was longer than 36 days.

As noted above, all the process and injury factors found to be influencing early mortality in the one- and two-year mortality cases are interlinked. However, they do provide a starting point from which to develop a decision-making model relevant to our context. To validate these candidate exposures, they will first need to be tested in a similar population or setting (for example, in patients with traumatic brain injuries). After testing they will need to be validated in a different clinical setting or population. These validation stages are to ensure that the results can be replicated in different clinical settings and populations. It will also allow one to assess the plausibility of candidate exposures identified here. The final stage would entail impact analysis and require the implementation of a randomised controlled trial with risk stratification being determined by the decision-making model or decisions based on clinical experience.

CHAPTER EIGHT

CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

8.1 INTRODUCTION

This chapter summarises the main results and conclusions, as highlighted in the previous chapters of this thesis. Furthermore, it highlights the study's limitations and recommendations. The overall aim of this study is to contribute to the development of a healthcare decision-making model grounded in existing processes of care and implemented guidelines, which can facilitate the prediction of survival in persons who have sustained a traumatic spinal cord injury (tSCI). To achieve this, Donabedian's model of care and Krause's theoretical risk model were combined, as the former only assessed process measures. As highlighted in the findings of this study, factors impacting survival are multifaceted. Therefore, a more comprehensive approach was needed in determining those factors responsible for reduced survival. Currently, no form of decision-making model is available to guide who should be prioritised for life-saving interventions that could promote survival in a resource constraint context. As noted, if patients are managed appropriately, it greatly increases their chances of survival.

8.2 SUMMARY

8.2.1 Summary of methodology

The study employed a quantitative approach, and the design was longitudinal and prospective in nature. Participants were followed up from the date of onset of injury till two years post-injury.

Data were collected at three points: admission, discharge, and one/two years post-injury. Data regarding personal and process factors were captured using a self-developed data extraction form based on the spinal cord injury (SCI) core basic data set form, International Standards of Neurological Classification, Spinal Cord Injury Secondary Conditions Scale, and process measures as identified in current literature.

Chapter three employed a rapid review methodology which sought to identify the predictors of early mortality in persons who sustained a tSCI. The predictors identified in this chapter were then used to inform the choice of candidate exposures concerning the one-year mortality cases outlined in Chapter 6. These candidate exposures were the personal and process factors captured on admission and discharge from acute care. Chapter 6 then used a case series methodology to describe and discuss the influence of these contextually relevant exposures on the participants' risk of early mortality.

8.2.2 Summary of results

The figure below outlines the steps that were followed in developing the preliminary descriptive decision-making model for survival following tSCI.

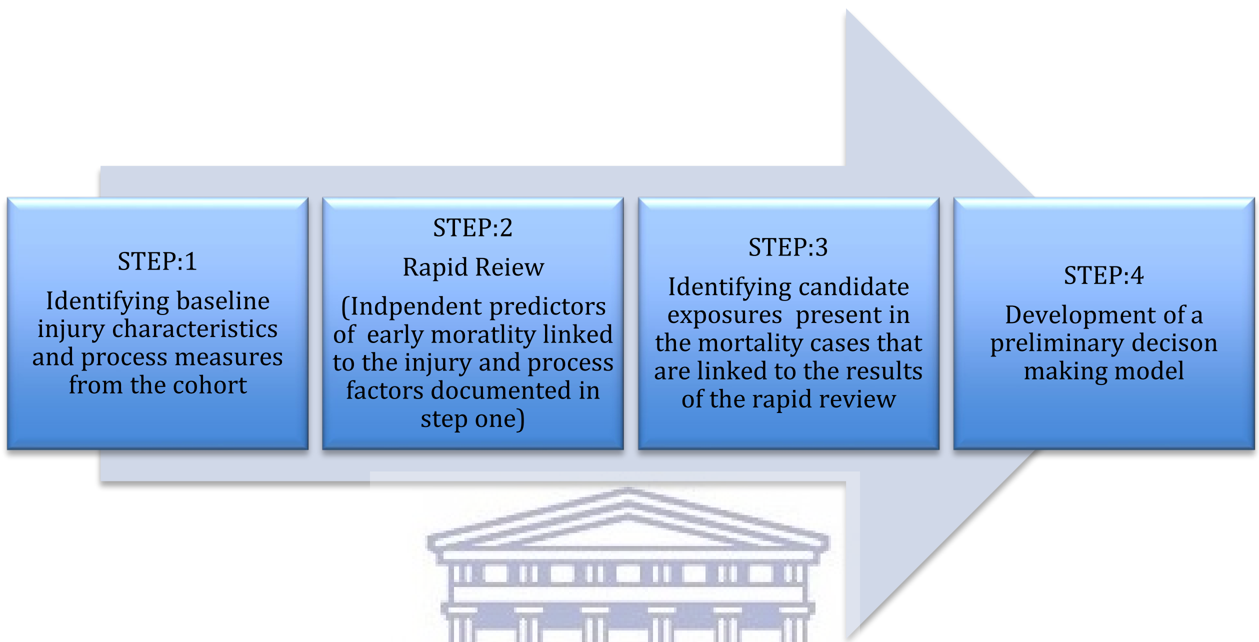


Figure 8.1 Steps followed in developing the preliminary decision-making model

As noted in Chapter one, the aim of this study was to contribute to the development of a decision-making model. This entailed identifying contextually relevant candidate exposures (routinely captured in clinical practice in the local context) which are supported by existing literature. Based on the summary of results from Chapters 3, 5 and 6, it was found that the variables (i.e., [Krause's Theoretical risk Model: age, gender, ASIA classification, mechanism of injury, vertebral injuries, associated injuries], [Donabedian's model of care: intermittent hospitalisation/delayed access to specialised care, surgery status/ time to surgery, screening/presence of secondary complications]) mentioned below may have positively influenced early mortality.

8.2.2.1 STEP: 1

Regarding the epidemiological profile (see Table 1.1), the majority of persons who sustained a tSCI were males. The highest number of injuries occurred within the age categories of 18-30 years. A larger percentage of participants were classified as paraplegics than those classified as tetraplegics. The most common American Spinal Injury Association (AISA) level being ASIA A and D. Assault cases, which consisted of gunshot, stabbing and blunt force-related aetiology, accounted for the largest number of tSCI-related injuries. The number of participants classified with complete and incomplete spinal lesions was evenly split. Baseline injury characteristics such as level of injury (i.e., tetraplegia), ASIA classification (A) and surgery status (yes/no) were fundamental predictors in determining the total length of hospital stay, while male (yes/no) and motor vehicle accident-related aetiology (yes/no) were found to be predictors of spinal surgery.

Process factors such as delayed time to specialised care and spinal surgery have been found to influence patient prognosis negatively. As found in this study, not all patients were transferred directly to Groote Schuur Hospital (GSH) for specialist care. This may be due to inappropriate transfer logistics or the need to stabilise patients first prior to receiving specialised care. In addition to this result, the majority of participants within this cohort were found to have received delayed surgical intervention. A rather interesting finding was that six of the one-year mortality cases who received spinal surgery did not survive, while three of the second-year mortality cases who received spinal surgery did not survive (See Table 6.3). This novel finding should be further investigated when validating the preliminary decision-making outlined in Table 8.1 below. Lastly, patients who were managed at the specialised SCI unit presented with a high proportion of vertebral and associated injuries.

8.2.2.2 STEP: 2

The rapid review conducted to identify candidate exposures of early mortality in persons with tSCI were found to relate primarily to injury factors as per Krause's Theoretical risk model. Baseline injury characteristics on admission were found to be fundamental predictors of early mortality, with many of these being non-modifiable. This highlights the importance of measures aimed at preventing the occurrence of tSCIs as these injuries usually result from preventable causes (Von Groote et al., 2014). The predictors identified by the rapid review were then used to determine which candidate exposures identified in the literature were present in the mortality cases.

8.2.2.3 STEP: 3

Participants who demised within the first and second year post-injury were relatively young with most cases falling within the age categories of 18-30 years and 31-45 years. As noted in the larger cohort, the predominant cause of injuries in these cases related to assault and transport related aetiology. These patients also had a high number of secondary complications present, which could have predisposed them to early mortality. Although the exact cause of death was not known for those participants who had died, one can conclude that the causes of early mortality are multifactorial (i.e., injury/personal and process-related factors) and cannot be linked solely to one specific factor. This is consistent with the results from the studies conducted by Krause. However, more context-specific data is required in relation to this.

8.2.2.4 STEP: 4

Table 8.1 below provides a preliminary, descriptive decision-making model which is grounded in evidence-based literature. and empirical findings from the primary study conducted in this project. These findings provide the basis for further validation of these factors in larger prospective, or retrospective, case control studies.

Table 8.1 Preliminary decision-making model based

Exposure	Category
Age *(Risk of mortality increases with advancing age)*	• 18-30 • 31-45 • 46-60 • ≥ 61
Gender *(Males engage in more risker lifestyles than females)*	• Male • Females
Mechanism of injury	• Falls

(Transport- and fall-related injuries are associated with higher injury severity scores = higher risk mortality)	• Transport • Assault
Intermittent hospitalisation (*Indirect transfer to specialised SCI units impacts patient prognosis)*	• ≤ 1 • ≥ 2
Associated injuries by area *(Patients who present with polytraumas are at a higher risk of early mortality)*	• Head • Neck • Upper limbs • Chest • Abdomen • Pelvis • Lower limbs
Vertebral injuries by location	• Cervical

(High and Low cervical injuries are at a higher risk of early mortality)	• Thoracic • Lumbar
ASIA classification on admission *(Patients classified as an ASIA A are at an increased risk of early mortality)*	• ASIA A • ASIA B • ASIA C • ASIA D
Spinal surgery status	• Yes • No
Time to spinal surgery *(Delayed surgery increases risk of developing secondary complications which in turn influences chances of survival)*	• ≤ 3 days • ≥ 3 days
Secondary complications *(Secondary medical complications specifically related to pneumonia, pressure ulcers and urinary tract infections have been linked to* ***mortality*** *and morbidity)*	• Pneumonia • Pressure ulcers • Urinary tract infections

8.3 CONCLUSION

The researcher sought to answer the following research question *"What are the variables and their utility in informing the development of a health care decision making model for the prediction of survival in persons with tSCI?"* In response to this question, the researcher found that mortality is multifactorial and variables predictive of early mortality may not necessarily behave the same in different contexts. This is evident in the results of the rapid review, which identified a wide spectrum of predictors. Therefore, this study sought to identify contextually relevant candidate exposures based on:

- personal factors such as age, gender, place of residence, aetiology, the severity of injury [complete/incomplete] level of injury [paraplegia/tetraplegia], spinal injury level, and ASIA classification; and
- process factors that are, time to acute care from intermediate hospitalisation, time to acute in-hospital physiotherapy treatment, time to surgery, screening of secondary complications, length of acute care stay [ICU/high-care], total length of hospital stay, and total length of cute in-hospital physiotherapy) documented in the results of this study.

To the researcher's knowledge, this is the first study in the South African context which has sought to identify predictors which influence early mortality of persons with tSCI. Furthermore, it is the first step in attempting to unravel the factors which place persons with a tSCI at an increased risk of mortality. By identifying these predictors, the researcher has addressed the overall aim of this study which is *"to contribute to the development of a healthcare decision-making model grounded in existing processes of care and* *implemented guidelines, which can facilitate the prediction of survival in persons who have sustained a tSCI"*. Although this is the case, these findings should undergo larger scale validation to inform its utility in the South African context. However, this was beyond the scope and time-frame of this study.

8.4 RECOMMENDATIONS

8.4.1 Service recommendations

First, the majority of the causes of tSCI in the larger cohort and that of mortality cases were related to assault transport and fall. Considering that the mechanism of injury may influence early, ways in which to prevent these traumatic injuries should be encouraged. Preventative measures could include interventions such as education and policy changes that may reduce the occurrence of tSCIs and the health complication that is associated with it. Reinforcing current education practices regarding using seatbelts and testing that a vehicle is roadworthy before driving is important. Furthermore, education regarding being intoxicated or using substances that may increase the likelihood of being involved in riskier behaviour (Tamás et al., 2019) should be encouraged. Furthermore, these interventions should target males as they are more inclined to engage in risky or dangerous behaviour than their female counterparts. This is substantiated by the current study where males accounted for the highest number of motor vehicle and assault-related injuries. With a high rate of crime and unemployment in South Africa, you may find individuals engaging in high-risk behaviour not just out of boredom but rather because of a need to support their family and themselves financially. Policy changes should be enforced, and if the public does not adhere to these changes, heftier penalties may be put in place to deter individuals from engaging in activities that may place themselves at a higher risk of injury. The penalties may specifically target those individuals who drive under the influence of alcohol or any other narcotic substance and those who find themselves engaging in interpersonal violence.

Second, patients within the larger cohort and from the mortality cases were not transported to GSH for specialist care but rather admitted to intermediary facilities, such as district hospitals and community health clinics. Based on this result, a deliberate attempt must be made to improve the timely access to specialised SCI services. To achieve this, the decentralisation of trauma care services for tSCI management might be the first point of call. As noted above, this delay in specialised acute care may negatively impact patient prognosis and increase a patient's probability of reduced survival in certain instances. However, if decentralisation of specialised care services is not possible, then another option would be to strengthen SCI management through the creation of and investment in centres of SCI excellence.

Third, the prevalence of secondary complications during acute care, as found in this study, remains relatively high. The issue regarding the development of secondary complications is a rather alarming problem which influences the length of persons' length of hospital stay, morbidity and mortality of persons who sustained tSCI. Although not directly accessed in this study, the occurrence of pressure ulcers may point directly to the possible lack of knowledge regarding the importance of turning, pressure relief, and techniques to turn patients with spinal fractures. The same can be mentioned for the occurrence of UTIs and other respiratory complications. UTIs can be prevented by using an alternative mode of catheterisation. Although each has its own advantages and disadvantages, evaluating which mode of catheterisation should be used can positively influence process factors such as the length of hospital stay. It is recommended that patients use intermittent catheterisation as opposed to other types owing to the reduced risk of urinary tract infections. However, decisions such as these should be made considering the patient's preferences and the resources available to the healthcare facility in question. The use of hydrophilic catheters should be advocated for as it reduces injury to the urethra during insertion and is considered to be more sterile than their non – hydrophilic counterparts (Li et al., 2013). Although more research is required, this mode of catheterisation has been found to be more cost-effective and result in improved patient outcomes (Xi et al., 2021), which is important if we wish to reduce the length of hospital stays and improve patient outcomes. Decisions such as these should be done in a consultative manner which includes feedback from the whole disciplinary team. As neurological function and quality of life are important for persons following the onset of injury it is integral to identify those core baseline characteristics which may affect neurological function following surgery.

Fourth, delayed spinal surgical surgery was a common occurrence. The majority of participants underwent spinal surgery only after three days. This is obviously not aligned to best practice guidelines but is normal within our context. Possible interventions that may remedy this could include more theatre time dedicated to performing these surgeries and a larger skilled surgical workforce to handle a high patient load.

Fifth, as seen in several of the mortality cases, the presence of pre-existing comorbidities may increase the allostatic load placed on patients predisposing them to early mortality. To address this problem, primary healthcare structures should also be strengthened to ensure the survival of persons who sustained a tSCI. It is a known fact that the presence of pre-existing comorbidities increases the risk of early mortality in this group. Therefore, if prevention is provided at a primary level, one could lessen the impact of comorbidities on someone's life if they sustain a debilitating injury such as a spinal cord injury or disease.

Sixth, associated and vertebral injuries are a highly prevalent occurrence within the mortality cases and the larger cohort. As noted in the literature, patients who present with polytrauma are at an increased probability of survival. Therefore, objectively determining injury severity on admission to the trauma facility is important. To achieve this, the ISS can be used. Patients with a high ISS ≥ 15, which is a measure used to quantify severity in polytrauma cases, were consistently at a higher risk of early mortality following injury. This was found to be a consistent predictor of early mortality in the result of the rapid review. As found in this study, certain aetiologies, such as fall and transport-related injuries demonstrate a greater risk for mortality. Both of the aforementioned causes of injuries are usually associated with higher injury severity scores (Palmer, 2007) than when compared to other forms of trauma-related injury. Thus, increasing their likelihood of adverse patient outcomes such as death. However, the trauma facility at GSH does not utilise the ISS during triaging patients. Considering its usefulness in stratifying patients into either low or high risk of early mortality, it is advisable for trauma units managing persons with SCI to use this tool.

Seventh, an integrated health information system should also be explored within our setting for persons with tSCI as it would be beneficial, especially concerning clinical decision-making and to boost epidemiological data related to this population group. Options to improve the quality of the data collected for persons with tSCI could include the use of standardised reporting forms and electronic medical records. Therefore, the SCI core basic data set form should always be used when capturing baseline injury data following a tSCI. Doing so will facilitate the capturing of data in a standardised manner, thereby assisting in monitoring the epidemiological profile of persons with tSCI and assisting in improving quality assurance measures. The implementation of an SCI registry, most notably a trauma registry, will assist in the long-term monitoring of persons who have sustained a tSCI. By doing so, one would be able to determine what baseline injury characteristics influence patient longevity in the long term. Furthermore, it will also facilitate yearly follow-ups to screen and provide self-management advice which is crucial in preventing secondary health conditions. In addition, if trauma and SCI registries are structured the same across developing countries, one would be able to merge data, thus creating a more holistic picture to inform African-inspired pathways of care to optimise survival and functioning within current resource constraints. Lastly, consideration should also be made regarding the de-escalation of yearly follow-ups to primary care level, provided an appropriate workforce is in place to manage SCIs.

Lastly, as noted above, being able to predict survival in low-middle-income countries (LMIC) such as South Africa allows one to successfully stratify patients into high- or low-risk groupings. This process of risk stratification provides a more objective mechanism in which to allocate specialised rehabilitation services. Meaning, patients who are at a higher risk of early mortality should receive a more intensive rehabilitation package to improve their chances of survival and prognosis, compared to those who are considered low risk. This is especially necessary within the South African context that is a resource constrained environment.

8.4.2 Recommendations for further research

First, validating the candidate exposures identified in this preliminary, descriptive decision-making model is necessary. This would be the first step to identifying factors of proximity to mortality and their strength of association. In addition, factor analysis could be conducted to ensure that only independently associated factors remain in the model to predict survival. Following the confirmation of predictors and validation, an impact study will need to be conducted to determine how the tool performs in relation to clinical decisions purely being made on clinical experience. Furthermore, an impact study will also facilitate the implementation of the tool within the clinical setting as it would assist in determining which clinical decision support systems would be best to encourage its uptake.

Second, further research is needed concerning novel ways to make medical records more accessible while still considering privacy. One such novel technique may involve the use of block chain technology which is commonly being used in the context of cryptocurrency (Chenthara et al., 2020). Using such technology can help create a more integrated healthcare system where data is easily accessible irrespective of where the patient and healthcare practitioner may be situated. In addition, it will provide researchers with a larger pool from which to harness clinical data that can be pertinent for decision-making processes.

Third, additional research is needed regarding the process that needs to be followed if a decentralised healthcare approach is to be used for tSCI management in South Africa. The possible barriers and facilitators should first be identified before any definitive steps are taken concerning this approach to specialised care in a developing context. If a clear pathway exists with respect to how a decentralised trauma network should be established, we could then determine what is needed in terms of resources and personnel to provide timely care.

Fourth, to prevent the increase of tSCIs, alternative modes of knowledge translation to bring about behaviour change should be explored. It seems as if awareness programmes currently being used are not achieving the desired goals.

Lastly, further research is needed to understand the factors influencing decision-making regarding the candidacy for spinal surgery. As it was found in this study that a higher proportion of patients who underwent surgery died within the first year post-injury. In addition, factors influencing time to spinal surgery should be investigated.

8.5 LIMITATIONS

Some of the methodological considerations that may have impacted the internal validity of this study relate to the availability of medical records. Medical folders were not always readily available at medical records once patients were discharged, as some needed to be processed first within the medicolegal department. In addition to the accessibility of medical records, patients who were first managed at non-specialised, or managed at district healthcare facilities were subjected to different care pathways, which would have impacted patient outcomes upon discharge. Very little was known about the care received and complications developed in previous episodes of care, which would have impacted the recovery trajectory of the patients.

8.5.1 Factors negatively influencing internal and external validity

- Only one government-funded tertiary healthcare facility was included as this facility is the only specialised SCI unit that manages 80% of persons with tSCI in the Cape Metropole region.
- A noticeable drawback is that results are not generalisable to other settings besides that of the Cape Metropolitan area. This lack of generalisability would be attributed to differences in care processes and gross domestic product spent on healthcare services between provinces. For e.g., EMS in urban settings and proximity to

specialised centres is better in urban setting than when compared to rural setting. Another example would be access to specialised equipment and resources.

- As the study employed a prospective study design, the loss to follow up was a noticeable limitation. Following up on participants to determine vital status proved challenging because participants either did not have a fixed abode or their contact details changed from the time at the onset of injury. Furthermore, participants recruited into this study were from suburbs within the Cape Metropole area that had a relatively high level of violence and crime and posed a potentially high risk for researchers to enter these areas to obtain follow-up data. A verbal autopsy was also not possible as there was no guarantee that the person spoken to telephonically was in fact the patient in question. Furthermore, verbal/written autopsy was used instead of determining the patient's actual cause of death via a medical autopsy which is seen as the gold standard.
- Due to the lack of standardised reporting throughout the patient care pathway, missing data may result in the underestimation of personal and process measure factors that are important for the development of preventative measures.
- The severity of secondary medical complications encountered during the participants length of hospital stay was often omitted from the medical records of patients as captured by the attending physician which only indicated the presence of a particular complication. A quantifiable way in which to measure severity may have given more insight concerning how secondary medical complications influence early mortality in persons with tSCI.

- The COVID-19 pandemic also posed its own challenges. When it started, the researcher was still reviewing the medical folders of patients who had missing data upon discharge from GSH. In the absence of physical follow ups, the Biomedical Research ethics Committee at the University of Western Cape granted the use of death registries which were linked to the South African Medical Research Council (SAMRC) burden of disease unit. Due to the severity of the first three waves of COVID-19, research access to all healthcare facilities was restricted. Therefore, this impacted the researcher's ability to address the gaps in the dataset. There was also uncertainty with respect to how long the pandemic would last. Hence, no definitive plans could be made going forward. It was then decided to use the available data to continue with the study as it was not sure when access to the facility in question would be granted. Although this is the case, the study employed a total consecutive population sampling technique which reduces the degree of bias, thus increasing the generalisability of the findings of this study.

8.5.2 Factors positively influencing internal and external validity

- To enhance internal validity, the same resident clinicians conducted the neurological classification, screening of complications and completing medical records, using international standards and psychometrically sound outcome measures. Furthermore, data elements included were considered objective and used standardised formatting, for example, time to surgery, time to acute care, secondary medical complications and length of hospital stay per the SCI core basic set form.

- In addition, the sampling frame of the current study covered a wide geographical area, and the epidemiological profile of the current study is comparable with previous reports, enhancing the external validity to some extent. In both the current study and Joseph et al. (2015), male patients within the age category of 18-30 were found to account for highest number of tSCI. In addition, the current study found that 67 per cent (37/55) of participants who were defined as having complete lesions were characterised as being paraplegic, compared to those patients who were found to have complete lesions and characterised as tetraplegic (32.7%,18/55). This was similar to the results by Joseph et al. (2015) who found that there were significantly more persons with paraplegia with complete injuries (50%) compared to those with tetraplegia (28.6%).

REFERENCE LIST

Aarabi, B., Harrop, J. S., Tator, C. H., Alexander, M., Dettori, J. R., Grossman, R. G., Fehlings, M. G., Mirvis, S. E., Shanmuganathan, K., Zacherl, K. M., Burau, K. D., Frankowski, R. F., Toups, E., Shaffrey, C. I., Guest, J. D., Harkema, S. J., Habashi, N. M., Andrews, P., Johnson, M. M., & Rosner, M. K. (2012). Predictors of pulmonary complications in blunt traumatic spinal cord injury. *Journal of neurosurgery. Spine, 17*(1 Suppl), 38-45. https://doi.org/10.3171/2012.4.AOSPINE1295

Abbasi, F., & Korooni, S. (2018). Infectious complications after spinal cord injury. *Essentials of Spinal Cord Injury Medicine, 13*, 91.

Abrassart, S., Stern, R., & Peter, R. (2009). Morbidity associated with isolated iliac wing fractures. *Journal of Trauma and Acute Care Surgery, 66*(1), 200-203.

Adams, S. T., & Leveson, S. H. (2012). Clinical prediction rules. *bmj, 344*.

Ahoniemi, E., Pohjolainen, T., & Kautiainen, H. (2011). Survival after spinal cord injury in Finland. *Journal of rehabilitation medicine, 43*(6), 481-485.

Ahuja, C. S., Badhiwala, J. H., & Fehlings, M. G. (2020, Sep). "Time is spine": the importance of early intervention for traumatic spinal cord injury. *Spinal Cord, 58*(9), 1037-1039. https://doi.org/10.1038/s41393-020-0477-8

Ahuja, C. S., Wilson, J. R., Nori, S., Kotter, M. R., Druschel, C., Curt, A., & Fehlings, M. G. (2017). Traumatic spinal cord injury. *Nature reviews Disease primers, 3*(1), 1-21.

Akobeng, A. K. (2007). Understanding diagnostic tests 1: sensitivity, specificity and predictive values. *Acta paediatrica, 96*(3), 338-341.

Alimohammadi, E., Ahadi, P., Rezaee, C., Safari-Faramani, R., Bagheri, S. R., & Janatolmakan, M. (2020). Acute traumatic quadriplegia: Predictors of in-hospital and six-month mortality [Article]. *Trauma, 22*(4), 300-306. https://doi.org/10.1177/1460408620909005

Alsaleh, K., Bednar, D., & Farrokhyar, F. (2017). Acute traumatic quadriplegia in adults: predictors of acute in-hospital mortality. *Turk Neurosurg, 27*(6), 942-945.

American College of Surgeons. (2018). 10th Edition of the Advanced Trauma Life Support® (ATLS®) Student Course Manual.

American Spinal Injury Association. (1984). Standards for neurological classification of spinal injury patients. *Chicago: American Spinal Injury Association*.

Anderson, D., Dumont, S., Azzaria, L., Bourdais, M. L., & Noreau, L. (2007). Determinants of return to work among spinal cord injury patients: A literature review. *Journal of Vocational Rehabilitation, 27*(1), 57-68.

Badhiwala, J. H., Ahuja, C. S., & Fehlings, M. G. (2018). Time is spine: a review of translational advances in spinal cord injury: JNSPG 75th Anniversary Invited Review Article. *Journal of Neurosurgery: Spine, 30*(1), 1-18.

Bae, J.-M. (2014). The clinical decision analysis using decision tree. *Epidemiology and health, 36*.

Balas, M., Guttman, M. P., Badhiwala, J. H., Lebovic, G., Nathens, A. B., Da Costa, L., Zador, Z., Spears, J., Fehlings, M. G., & Wilson, J. R. (2022). Earlier Surgery Reduces Complications in Acute Traumatic Thoracolumbar Spinal Cord Injury: Analysis of a Multi-Center Cohort of 4108 Patients. *Journal of neurotrauma, 39*(3-4), 277-284.

Banaszek, D., Inglis, T., Ailon, T., Charest-Morin, R., Dea, N., Fisher, C. G., Kwon, B. K., Paquette, S. J., & Street, J. (2019a). P152. The effect of frailty on outcome after traumatic spinal cord injury [Article]. *Spine Journal, 19*, S228-S229. https://doi.org/10.1016/j.spinee.2019.05.577

Banaszek, D., Inglis, T., Ailon, T., Charest-Morin, R., Dea, N., Fisher, C. G., Kwon, B. K., Paquette, S. J., & Street, J. (2019b). P153. Sarcopenia, independent of age, predicts mortality and acute care adverse events in patients with traumatic spinal cord injury [Article]. *Spine Journal, 19*, S229-S229. https://doi.org/10.1016/j.spinee.2019.05.578

Banaszek, D., Inglis, T., Marion, T. E., Charest-Morin, R., Moskven, E., Rivers, C. S., Kurban, D., Flexman, A. M., Ailon, T., & Dea, N. (2020). Effect of Frailty on Outcome after Traumatic Spinal Cord Injury. *Journal of neurotrauma, 37*(6), 839-845.

Barclay, L., & Hilton, G. M. (2019). A scoping review of peer-led interventions following spinal cord injury. *Spinal Cord, 57*(8), 626-635.

Baricich, A., Amico, A. P., Zampolini, M., Gimigliano, F., Cisari, C., & Fiore, P. (2017, Feb). People with Spinal Cord Injury in Italy. *Am J Phys Med Rehabil, 96*(2 Suppl 1), S80-S82. https://doi.org/10.1097/PHM.0000000000000573

Barman, A., Shanmugasundaram, D., Bhide, R., Viswanathan, A., Magimairaj, H. P., Nagarajan, G., Arumugam, E., Tharion, G., & Thomas, R. (2014). Survival in persons with traumatic spinal cord injury receiving structured follow-up in South India. *Archives of Physical Medicine and Rehabilitation, 95*(4), 642-648. https://doi.org/10.1016/j.apmr.2013.11.003

Berlowitz, D. J., Wadsworth, B., & Ross, J. (2016). Respiratory problems and management in people with spinal cord injury. *Breathe, 12*(4), 328-340.

Biering-Sørensen, F., Devivo, M., Charlifue, S., Chen, Y., New, P., Noonan, V., Post, M., & Vogel, L. (2017). International spinal cord injury core data set (version 2.0)—including standardization of reporting. *Spinal Cord, 55*(8), 759-764.

Biering-Sørensen, F., & Noonan, V. K. (2016). Standardization of data for clinical use and research in spinal cord injury. *Brain sciences, 6*(3), 29.

Blex, C., Kreutzträger, M., Ludwig, J., Nowak, C. P., Schwab, J. M., Lübstorf, T., Ekkernkamp, A., Kopp, M. A., & Liebscher, T. (2022). Baseline predictors of in-hospital mortality after acute traumatic spinal cord injury: data from a level I trauma center. *Scientific Reports, 12*(1), 1-12.

Bokhari, A. R., Sivakumar, B., Sefton, A., Lin, J. L., Smith, M. M., Gray, R., & Hartin, N. (2019). Morbidity and mortality in cervical spine injuries in the elderly. *ANZ journal of surgery, 89*(4), 412-417.

Bonnett, L. J., Snell, K. I., Collins, G. S., & Riley, R. D. (2019). Guide to presenting clinical prediction models for use in clinical settings. *bmj, 365*.

Booysen, F. (2003). Urban–rural inequalities in health care delivery in South Africa. *Development Southern Africa, 20*(5), 659-673.

Bourassa-Moreau, É., Mac-Thiong, J.-M., Feldman, D. E., Thompson, C., & Parent, S. (2013). Complications in acute phase hospitalization of traumatic spinal cord injury: does surgical timing matter? *Journal of Trauma and Acute Care Surgery, 74*(3), 849-854.

Brauns, M., & Stanton, A. (2016). Governance of the public health sector during Apartheid: The case of South Africa. *Journal of Governance and Regulation/Volume, 5*(1).

Brown, R., Dimarco, A. F., Hoit, J. D., & Garshick, E. (2006). Respiratory dysfunction and management in spinal cord injury. *Respiratory care, 51*(8), 853-870.

Bryce, T. N., Budh, C. N., Cardenas, D. D., Dijkers, M., Felix, E. R., Finnerup, N. B., Kennedy, P., Lundeberg, T., Richards, J. S., & Rintala, D. H. (2007). Pain after spinal cord injury: an evidence-based review for clinical practice and research: report of the National Institute on Disability and Rehabilitation Research Spinal Cord Injury Measures meeting. *The journal of spinal cord medicine, 30*(5), 421-440.

Budd, M. A., Gater Jr, D. R., & Channell, I. (2022). Psychosocial Consequences of Spinal Cord Injury: A Narrative Review. *Journal of Personalized Medicine, 12*(7), 1178.

Burger, R., & Christian, C. (2020). Access to health care in post-apartheid South Africa: availability, affordability, acceptability. *Health Economics, Policy and Law, 15*(1), 43-55.

Burns, A. S., Marino, R. J., Kalsi-Ryan, S., Middleton, J. W., Tetreault, L. A., Dettori, J. R., Mihalovich, K. E., & Fehlings, M. G. (2017). Type and timing of rehabilitation following acute and subacute spinal cord injury: a systematic review. *Global spine journal, 7*(3_suppl), 175S-194S.

Burns, A. S., & O'connell, C. (2012). The challenge of spinal cord injury care in the developing world. *The journal of spinal cord medicine, 35*(1), 3-8.

Burns, A. S., Santos, A., Cheng, C. L., Chan, E., Fallah, N., Atkins, D., Dvorak, M. F., Ho, C., Ahn, H., Paquet, J., Kwon, B. K., & Noonan, V. K. (2017, Oct 15). Understanding Length of Stay after Spinal Cord Injury: Insights and Limitations from the Access to Care and Timing Project. *J Neurotrauma, 34*(20), 2910-2916. https://doi.org/10.1089/neu.2016.4935

Burns, S. P. (2007). Acute respiratory infections in persons with spinal cord injury. *Physical Medicine and Rehabilitation Clinics of North America, 18*(2), 203-216.

Campos, I., Margalho, P., Lopes, A., Branco, C., Faria, F., Caldas, J., Cunha, M., Andrade, M. J., & Lains, J. (2017). People with spinal cord injury in Portugal. *American journal of physical medicine & rehabilitation, 96*(2), S106-S108.

Cao, Y., Dipiro, N., & Krause, J. S. (2019, Jul). Health factors and spinal cord injury: a prospective study of risk of cause-specific mortality. *Spinal Cord, 57*(7), 594-602. https://doi.org/10.1038/s41393-019-0264-6

Cao, Y., Krause, J., & Dipiro, N. (2013). Risk factors for mortality after spinal cord injury in the USA. *Spinal Cord, 51*(5), 413-418.

Chamberlain, J. D., Meier, S., Mader, L., Von Groote, P. M., & Brinkhof, M. W. (2015). Mortality and longevity after a spinal cord injury: systematic review and meta-analysis. *Neuroepidemiology, 44*(3), 182-198. https://doi.org/10.1159/000382079

Cheng, C. L., Plashkes, T., Shen, T., Fallah, N., Humphreys, S., O'connell, C., Linassi, A. G., Ho, C., Short, C., & Ethans, K. (2017). Does specialized inpatient rehabilitation affect whether or not people with traumatic spinal cord injury return home? *Journal of neurotrauma, 34*(20), 2867-2876.

Chenthara, S., Ahmed, K., Wang, H., Whittaker, F., & Chen, Z. (2020). Healthchain: A novel framework on privacy preservation of electronic health records using blockchain technology. *PloS one, 15*(12), e0243043.

Chhabra, H. S., Sharawat, R., & Vishwakarma, G. (2022). In-hospital mortality in people with complete acute traumatic spinal cord injury at a tertiary care center in India—a retrospective analysis. *Spinal Cord, 60*(3), 210-215.

Chiu, W.-T., Lin, H.-C., Lam, C., Chu, S.-F., Chiang, Y.-H., & Tsai, S.-H. (2010). Epidemiology of traumatic spinal cord injury: comparisons between developed and developing countries. *Asia Pacific Journal of Public Health, 22*(1), 9-18.

Choi, J., & Forrester, J. D. (2022). Clinical Prediction Tools in Trauma: Where Do We Go From Here? *JAMA network open, 5*(1), e2145867-e2145867.

Claridge, J. A., Croce, M. A., Weinberg, J. A., Forsythe, R. M., Miller, C., & Fabian, T. C. (2006). The real predictors of disposition in patients with spinal cord injuries. *Journal of Trauma and Acute Care Surgery, 60*(1), 178-186.

Claxton, A. R., Wong, D. T., Chung, F., & Fehlings, M. G. (1998). Predictors of hospital mortality and mechanical ventilation in patients with cervical spinal cord injury. *Canadian journal of anaesthesia = Journal canadien d'anesthesie, 45*(2), 144-149. http://search.ebscohost.com/login.aspx?direct=true&db=cmedm&AN=9512849&site=ehost-live

Conradsson, D., Phillips, J., Nizeyimana, E., Hilliar, C., & Joseph, C. (2019). Risk indicators of length of acute hospital stay after traumatic spinal cord injury in South Africa: a prospective, population-based study. *Spinal Cord, 57*(9), 763-769.

Conradsson, D., Rhoda, A., Mlenzana, N., Nilsson Wikmar, L., Wahman, K., Hultling, C., & Joseph, C. (2018). Strengthening Health Systems for Persons With Traumatic Spinal Cord Injury in South Africa and Sweden: A Protocol for a Longitudinal Study of Processes and Outcomes. *Frontiers in neurology, 9*, 453. https://doi.org/10.3389/fneur.2018.00453

Consortium for Spinal Cord, M. (2008). Early acute management in adults with spinal cord injury: a clinical practice guideline for health-care professionals. *The journal of spinal cord medicine, 31*(4), 403-479. https://doi.org/10.1043/1079-0268-31.4.408

Coovadia, H., Jewkes, R., Barron, P., Sanders, D., & Mcintyre, D. (2009). The health and health system of South Africa: historical roots of current public health challenges. *The Lancet, 374*(9692), 817-834.

Daneshvar, P., Roffey, D. M., Brikeet, Y. A., Tsai, E. C., Bailey, C. S., & Wai, E. K. (2013). Spinal cord injuries related to cervical spine fractures in elderly patients: factors affecting mortality. *The Spine Journal, 13*(8), 862-866.

Daverat, P., Gagnon, M., Dartigues, J., Mazaux, J., & Barat, M. (1989). Initial factors predicting survival in patients with a spinal cord injury. *Journal of Neurology, Neurosurgery & Psychiatry, 52*(3), 403-406.

De Graaf, M. A., Jager, K. J., Zoccali, C., & Dekker, F. W. (2011). Matching, an appealing method to avoid confounding? *Nephron Clinical Practice, 118*(4), c315-c318.

Derakhshanrad, N., Yekaninejad, M., Vosoughi, F., Sadeghi Fazel, F., & Saberi, H. (2016). Epidemiological study of traumatic spinal cord injuries: experience from a specialized spine center in Iran. *Spinal Cord, 54*(10), 901-907.

Devivo, M., Biering-Sørensen, F., Charlifue, S., Noonan, V., Post, M., Stripling, T., & Wing, P. (2006). International spinal cord injury core data set. *Spinal Cord, 44*(9), 535-540.

Divanoglou, A., & Levi, R. (2009). Incidence of traumatic spinal cord injury in Thessaloniki, Greece and Stockholm, Sweden: a prospective population-based study. *Spinal Cord, 47*(11), 796-801.

Divanoglou, A., Westgren, N., Seiger, Å., Hulting, C., & Levi, R. (2010). Late mortality during the first year after acute traumatic spinal cord injury: a prospective, population-based study. *The journal of spinal cord medicine, 33*(2), 117-127.

Donabedian, A. (1966). Evaluating the quality of medical care. *The Milbank memorial fund quarterly, 44*(3), 166-206.

Donner-Banzhoff, N. (2018). Solving the diagnostic challenge: a patient-centered approach. *The Annals of Family Medicine, 16*(4), 353-358.

Dookie, S., & Singh, S. (2012). Primary health services at district level in South Africa: a critique of the primary health care approach. *BMC family practice, 13*(1), 1-4.

Dorner, T., Grabovac, I., Mogg, C., Oberndorfer, M., & Haider, S. (2019). Frailty as predictor for all-cause and cause-specific mortality: 11-year follow-up cohort study. *European Journal of Public Health, 29*(Supplement_4), ckz187. 166.

Dvorak, M. F., Noonan, V. K., Fallah, N., Fisher, C. G., Finkelstein, J., Kwon, B. K., Rivers, C. S., Ahn, H., Paquet, J., & Tsai, E. C. (2015). The influence of time from injury to surgery on motor recovery and length of hospital stay in acute traumatic spinal cord injury: an observational Canadian cohort study. *Journal of neurotrauma, 32*(9), 645-654.

Eastwood, E. A., Hagglund, K. J., Ragnarsson, K. T., Gordon, W. A., & Marino, R. J. (1999). Medical rehabilitation length of stay and outcomes for persons with traumatic spinal cord injury—1990–1997. *Archives of Physical Medicine and Rehabilitation, 80*(11), 1457-1463.

El Masri, W. (2006). Traumatic spinal cord injury: the relationship between pathology and clinical implications. *Trauma, 8*(1), 29-46.

El Tallawy, H. N., Farghly, W. M., Badry, R., Rageh, T. A., Metwally, N. a. H., Shehata, G. A., Sayd, M. A., Hamed, Y., & Kandil, M. R. (2013). Prevalence of spinal cord disorders in Al-Quseir City, Red Sea Governorate, Egypt. *Neuroepidemiology, 41*(1), 42-47.

Epstein, N. E. (2014). A review article on the benefits of early mobilization following spinal surgery and other medical/surgical procedures. *Surgical neurology international, 5*(Suppl 3), S66.

Ernstberger, A., Koller, M., Zeman, F., Kerschbaum, M., Hilber, F., Diepold, E., Loss, J., Herbst, T., Nerlich, M., & Bavaria, T. C. O. T. T. N. O. E. (2018). A trauma network with centralized and local health care structures: Evaluating the effectiveness of the first certified Trauma Network of the German Society of Trauma Surgery. *PloS one, 13*(3), e0194292.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics, 5*(1), 1-4.

Facchinello, Y., Beauséjour, M., Richard-Denis, A., Thompson, C., & Mac-Thiong, J.-M. (2017). The use of regression tree analysis for predicting the functional outcome following traumatic spinal cord injury. *Journal of neurotrauma*(ja).

Fallah, N., Noonan, V. K., Waheed, Z., Rivers, C. S., Plashkes, T., Bedi, M., Etminan, M., Thorogood, N. P., Ailon, T., & Chan, E. (2022). Development of a machine learning algorithm for predicting in-hospital and 1-year mortality after traumatic spinal cord injury. *The Spine Journal, 22*(2), 329-336.

Fehlings, M. G., Cadotte, D. W., & Fehlings, L. N. (2011, Aug). A series of systematic reviews on the treatment of acute spinal cord injury: a foundation for best medical practice. *J Neurotrauma, 28*(8), 1329-1333. https://doi.org/10.1089/neu.2011.1955

Fehlings, M. G., Martin, A. R., Tetreault, L. A., Aarabi, B., Anderson, P., Arnold, P. M., Brodke, D., Burns, A. S., Chiba, K., & Dettori, J. R. (2017). A clinical practice guideline for the management of patients with acute spinal cord injury: recommendations on the role of baseline magnetic resonance imaging in clinical decision making and outcome prediction. *Global spine journal, 7*(3_suppl), 221S-230S.

Fehlings, M. G., Tetreault, L. A., Aarabi, B., Anderson, P., Arnold, P. M., Brodke, D. S., Chiba, K., Dettori, J. R., Furlan, J. C., Harrop, J. S., Hawryluk, G., Holly, L. T., Howley, S., Jeji, T., Kalsi-Ryan, S., Kotter, M., Kurpad, S., Kwon, B. K., Marino, R. J., Martin, A. R., Massicotte, E., Merli, G., Middleton, J. W., Nakashima, H., Nagoshi, N., Palmieri, K., Singh, A., Skelly, A. C., Tsai, E. C., Vaccaro, A., Wilson, J. R., Yee, A., & Burns, A. S. (2017, Sep). A Clinical Practice Guideline for the Management of Patients With Acute

Spinal Cord Injury: Recommendations on the Type and Timing of Rehabilitation. *Global Spine J, 7*(3 Suppl), 231S-238S. https://doi.org/10.1177/2192568217701910

Fehlings, M. G., Tetreault, L. A., Wilson, J. R., Aarabi, B., Anderson, P., Arnold, P. M., Brodke, D. S., Burns, A. S., Chiba, K., & Dettori, J. R. (2017). A clinical practice guideline for the management of patients with acute spinal cord injury and central cord syndrome: recommendations on the timing (≤ 24 hours versus> 24 hours) of decompressive surgery. *Global spine journal, 7*(3_suppl), 195S-202S.

[Record #588 is using a reference type undefined in this output style.]

Fischer, F., Lange, K., Klose, K., Greiner, W., & Kraemer, A. (2016). Barriers and strategies in guideline implementation—a scoping review. Healthcare,

Frankel, H., Coll, J., Charlifue, S., Whiteneck, G., Gardner, B., Jamous, M., Krishnan, K., Nuseibeh, I., Savic, G., & Sett, P. (1998). Long-term survival in spinal cord injury: a fifty year investigation. *Spinal Cord, 36*(4).

Fried, L. P., Ferrucci, L., Darer, J., Williamson, J. D., & Anderson, G. (2004). Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 59*(3), M255-M263.

Frielingsdorf, K., & Dunn, R. N. (2007). Cervical spine injury outcome–a review of 101 cases treated in a tertiary referral unit. *South African Medical Journal, 97*(3), 203-207.

Furlan, J. C., Bracken, M. B., & Fehlings, M. G. (2010). Is age a key determinant of mortality and neurological outcome after acute traumatic spinal cord injury? [Article]. *Neurobiology of Aging, 31*(3), 434-446. https://doi.org/10.1016/j.neurobiolaging.2008.05.003

Furlan, J. C., & Fehlings, M. G. (2009). The impact of age on mortality, impairment, and disability among adults with acute traumatic spinal cord injury. *Journal of neurotrauma, 26*(10), 1707-1717.

Furlan, J. C., Krassioukov, A., Miller, W. C., & Von Elm, E. (2010). Epidemiology of traumatic SCI. *Spinal cord injury rehabilitation evidence, 3*, 1-15.

Furlan, J. C., Noonan, V., Singh, A., & Fehlings, M. G. (2011). Assessment of impairment in patients with acute traumatic spinal cord injury: a systematic review of the literature. *Journal of neurotrauma, 28*(8), 1445-1477.

Furlan, J. C., Sakakibara, B. M., Miller, W. C., & Krassioukov, A. V. (2013, Jul). Global incidence and prevalence of traumatic spinal cord injury. *Can J Neurol Sci, 40*(4), 456-464. https://doi.org/10.1017/s0317167100014530

Garshick, E., Kelley, A., Cohen, S., Garrison, A., Tun, C., Gagnon, D., & Brown, R. (2005). A prospective assessment of mortality in chronic spinal cord injury. *Spinal Cord, 43*(7), 408-416.

Gillespie, B. M., Walker, R. M., Latimer, S. L., Thalib, L., Whitty, J. A., Mcinnes, E., & Chaboyer, W. P. (2020). Repositioning for pressure injury prevention in adults. *Cochrane Database of Systematic Reviews*(6).

Glennie, R., Bailey, C., Tsai, E., Noonan, V., Rivers, C., Fourney, D., Ahn, H., Kwon, B., Paquet, J., & Drew, B. (2017). An analysis of ideal and actual time to surgery after traumatic spinal cord injury in Canada. *Spinal Cord, 55*(6), 618-623.

Golestani, A., Shobeiri, P., Sadeghi-Naini, M., Jazayeri, S. B., Maroufi, S. F., Ghodsi, Z., Ohadi, M. a. D., Mohammadi, E., Ghodsi, S. M., & Rahimi-Movaghar, V. (2022). Epidemiology of traumatic spinal cord injury in developing countries from 2009 to 2020: a systematic review and meta-analysis. *Neuroepidemiology*.

Goosen, J., Bowley, D. M., Degiannis, E., & Plani, F. (2003). Trauma care systems in South Africa. *Injury, 34*(9), 704-708.

Gour-Provencal, G., Mac-Thiong, J.-M., Feldman, D. E., Bégin, J., & Richard-Denis, A. (2021). Decreasing pressure injuries and acute care length of stay in patients with acute traumatic spinal cord injury. *The journal of spinal cord medicine, 44*(6), 949-957.

Graves, D. E., Frankiewicz, R. G., & Donovan, W. H. (2006). Construct validity and dimensional structure of the ASIA motor scale. *The journal of spinal cord medicine, 29*(1), 39-45.

Griffin, M. R., O'fallon, W., Opitz, J. L., & Kurland, L. T. (1985). Mortality, survival and prevalence: traumatic spinal cord injury in Olmsted County, Minnesota, 1935–1981. *Journal of chronic diseases, 38*(8), 643-653.

Grobman, W. A., & Stamilio, D. M. (2006). Methods of clinical prediction. *American journal of obstetrics and gynecology, 194*(3), 888-894.

Guidi, J., Lucente, M., Sonino, N., & Fava, G. A. (2021). Allostatic load and its impact on health: a systematic review. *Psychotherapy and psychosomatics, 90*(1), 11-27.

Gupta, N. (2019). Lack of adequate care post spinal cord injury-a case report. *Spinal Cord Series and Cases, 5*(1), 1-4.

Gupta, N., Castillo-Laborde, C., & Landry, M. D. (2011). Health-related rehabilitation services: assessing the global supply of and need for human resources. *BMC Health Services Research, 11*(1), 1-11.

Hagen, E. M., Lie, S. A., Rekand, T., Gilhus, N. E., & Gronning, M. (2010). Mortality after traumatic spinal cord injury: 50 years of follow-up. *Journal of Neurology, Neurosurgery & Psychiatry, 81*(4), 368-373.

Hammoudeh, S., Gadelhaq, W., & Janahi, I. (2018). *Prospective cohort studies in medical research*. IntechOpen.

Harris, G., & Vermaak, C. (2015). Economic inequality as a source of interpersonal violence: Evidence from Sub-Saharan Africa and South Africa. *South African Journal of Economic and Management Sciences, 18*(1), 45-57.

Hartkopp, A., Brønnum-Hansen, H., Seidenschnur, A. M., & Biering-Sørensen, F. (1997). Survival and cause of death after traumatic spinal cord injury. A long-term epidemiological survey from Denmark. *Spinal Cord, 35*(2), 76-85.

Ho, C. H., Wuermser, L.-A., Priebe, M. M., Chiodo, A. E., Scelza, W. M., & Kirshblum, S. C. (2007). Spinal cord injury medicine. 1. Epidemiology and classification. *Archives of Physical Medicine and Rehabilitation, 88*(3), S49-S54.

Hossain, M. S., Harvey, L. A., Islam, M. S., Rahman, M. A., Glinsky, J. V., & Herbert, R. D. (2019). A prediction model to identify people with spinal cord injury who are at high risk of dying within 5 years of discharge from hospital in Bangladesh. *Spinal Cord, 57*(3), 198-205.

Hulley, S. B. (2007). *Designing clinical research*. Lippincott Williams & Wilkins.

Hylands, M., Toma, A., Beaudoin, N., Frenette, A. J., D'aragon, F., Belley-Côté, É., Charbonney, E., Møller, M. H., Laake, J. H., & Vandvik, P. O. (2017). Early vasopressor use following traumatic injury: a systematic review. *BMJ open, 7*(11), e017559.

Inglis, T., Banaszek, D., Rivers, C. S., Kurban, D., Evaniew, N., Fallah, N., Waheed, Z., Christie, S., Fox, R., Mac Thiong, J.-M., Ethans, K., Ho, C., Linassi, A. G., Ahn, H., Attabib, N., Bailey, C. S., Fehlings, M. G., Fourney, D. R., Paquet, J., Townson, A., Tsai, E., Cheng, C. L., Noonan, V. K., Dvorak, M. F., & Kwon, B. K. (2020). In-Hospital Mortality for the Elderly with Acute Traumatic Spinal Cord Injury. *Journal of neurotrauma*. https://doi.org/10.1089/neu.2019.6912

International Advanced Trauma Life Support Working Group. (2013). Advanced trauma life support (ATLS®): the ninth edition. *The journal of trauma and acute care surgery, 74*(5), 1363-1366.

Jensen, M., Truitt, A., Schomer, K., Yorkston, K., Baylor, C., & Molton, I. (2013). Frequency and age effects of secondary health conditions in individuals with spinal cord injury: a scoping review. *Spinal Cord, 51*(12), 882-892.

Joseph, C. (2017). Characteristics and outcomes of gunshot-acquired spinal cord injury in South Africa. *South African Medical Journal, 107*(6), 518-522.

Joseph, C., Andersson, N., Bjelak, S., Giesecke, K., & Hultling, C. (2017). Incidence, aetiology and injury characteristics of traumatic spinal cord injury in Stockholm, Sweden: a prospective, population-based update.

Joseph, C., Delcarme, A., Vlok, I., Wahman, K., Phillips, J., & Wikmar, L. N. (2015). Incidence and aetiology of traumatic spinal cord injury in Cape Town, South Africa: a prospective, population-based study. *Spinal Cord, 53*(9), 692-696.

Joseph, C., Scriba, E., Wilson, V., Mothabeng, J., & Theron, F. (2017). People with spinal cord injury in Republic of South Africa. *American journal of physical medicine & rehabilitation, 96*(2), S109-S111.

Joseph, C., & Wikmar, L. N. (2016). Prevalence of secondary medical complications and risk factors for pressure ulcers after traumatic spinal cord injury during acute care in South Africa. *Spinal Cord, 54*(7), 535-539.

Kalpakjian, C. Z., Scelza, W. M., Forchheimer, M. B., & Toussaint, L. L. (2007). Preliminary reliability and validity of a spinal cord injury secondary conditions scale. *The journal of spinal cord medicine, 30*(2), 131-139.

Kaminski, L., Cordemans, V., Cernat, E., M'bra, K. I., & Mac-Thiong, J.-M. (2017). Functional outcome prediction after traumatic spinal cord injury based on acute clinical factors. *Journal of neurotrauma, 34*(12), 2027-2033.

Kang, Y., Ding, H., Zhou, H., Wei, Z., Liu, L., Pan, D., & Feng, S. (2017). Epidemiology of worldwide spinal cord injury: a literature review. *Journal of Neurorestoratology, 6*, 1-9.

Kanna, R. M., Shetty, A. P., & Rajasekaran, S. (2021). Timing of intervention for spinal injury in patients with polytrauma. *Journal of Clinical Orthopaedics and Trauma, 12*(1), 96-100.

Kappen, T. H., Van Klei, W. A., Van Wolfswinkel, L., Kalkman, C. J., Vergouwe, Y., & Moons, K. G. (2018). Evaluating the impact of prediction models: lessons learned, challenges, and recommendations. *Diagnostic and prognostic research, 2*(1), 1-11.

Keleher, H. (2001). Why primary health care offers a more comprehensive approach to tackling health inequities than primary care. *Australian journal of primary health, 7*(2), 57-61.

Kennedy, G., & Gallego, B. (2019). Clinical prediction rules: a systematic review of healthcare provider opinions and preferences. *International journal of medical informatics, 123*, 1-10.

Khan, F., Qaisar, Bilal, H., Khan, S., Muhammad, Ahmad, N., Jaffar, M., Ayaz, M., & Khalid, S. (2018). The Prevalence of Traumatic Spinal Cord Injury in Khyber Pakhtunkhwa from 2008 to 2017: A Cross Sectional Study. *International Journal of Scientific & Engineering Research 9*(10).

Khan, O., Badhiwala, J. H., Wilson, J. R., Jiang, F., Martin, A. R., & Fehlings, M. G. (2019). Predictive modeling of outcomes after traumatic and nontraumatic spinal cord injury using machine learning: review of current progress and future directions. *Neurospine, 16*(4), 678.

Khosravi, S., Khayyamfar, A., Shemshadi, M., Koltapeh, M. P., Sadeghi-Naini, M., Ghodsi, Z., Shokraneh, F., Bardsiri, M. S., Derakhshan, P., & Komlakh, K. (2022). Indicators of quality of care in individuals with traumatic spinal cord injury: a scoping review. *Global spine journal, 12*(1), 166-181.

Kim, H., Cutter, G. R., George, B., & Chen, Y. (2018). Understanding and preventing loss to follow-up: experiences from the spinal cord injury model systems. *Topics in Spinal Cord Injury Rehabilitation, 24*(2), 97-109.

Kim, Y., Cho, M. H., Do, K., Kang, H. J., Mok, J. J., Kim, M. K., & Kim, G. S. (2021). Incidence and risk factors of urinary tract infections in hospitalised patients with spinal cord injury. *Journal of Clinical Nursing*.

Kirshblum, S., Snider, B., Eren, F., & Guest, J. (2021). Characterizing natural recovery after traumatic spinal cord injury. *Journal of neurotrauma, 38*(9), 1267-1284.

Kirshblum, S. C., Burns, S. P., Biering-Sorensen, F., Donovan, W., Graves, D. E., Jha, A., Johansen, M., Jones, L., Krassioukov, A., & Mulcahey, M. (2011). International standards for neurological classification of spinal cord injury (revised 2011). *The journal of spinal cord medicine, 34*(6), 535-546.

Knight, K. L. (2008). More precise classification of orthopaedic injury types and treatment will improve patient care. *Journal of athletic training, 43*(2), 117-118.

Kong, V., Bruce, J., Sartorius, B., Laing, G., Odendaal, J., Brysiewicz, P., & Clarke, D. (2019). Civilian cerebral gunshot wounds in rural South African patients are associated with significantly higher mortality rates than in urban patients. *European journal of trauma and emergency surgery, 45*(1), 145-150.

Kooistra, B., Dijkman, B., Einhorn, T. A., & Bhandari, M. (2009). How to design a good case series. *JBJS, 91*(Supplement_3), 21-26.

Krause, J. (1996). Secondary conditions and spinal cord injury: a model for prediction and prevention. *Topics in Spinal Cord Injury Rehabilitation, 2*(2), 58-70.

Krause, J. S. (1992). Employment after spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 73*(2), 163-169.

Krause, J. S., Carter, R. E., & Pickelsimer, E. (2009, Jan). Behavioral risk factors of mortality after spinal cord injury. *Arch Phys Med Rehabil, 90*(1), 95-101. https://doi.org/10.1016/j.apmr.2008.07.012

Krause, J. S., Carter, R. E., Pickelsimer, E. E., & Wilson, D. (2008, Aug). A prospective study of health and risk of mortality after spinal cord injury. *Arch Phys Med Rehabil, 89*(8), 1482-1491. https://doi.org/10.1016/j.apmr.2007.11.062

Krause, J. S., Saunders, L. L., & Acuna, J. (2012). Gainful employment and risk of mortality after spinal cord injury: effects beyond that of demographic, injury and socioeconomic factors. *Spinal Cord, 50*(10), 784-788. https://doi.org/10.1038/sc.2012.49

Krause, J. S., Zhai, Y., Saunders, L. L., & Carter, R. E. (2009). Risk of mortality after spinal cord injury: an 8-year prospective study. *Archives of Physical Medicine and Rehabilitation, 90*(10), 1708-1715.

Kutner, M. H., Nachtsheim, C. J., Neter, J., & Wasserman, W. (2004). *Applied linear regression models* (Vol. 4., p289). McGraw-Hill/Irwin New York.

Lee, B., Cripps, R. A., Fitzharris, M., & Wing, P. (2014). The global map for traumatic spinal cord injury epidemiology: update 2011, global incidence rate. *Spinal Cord, 52*(2), 110-116.

Leidel, B. A., Kanz, K. G., & Mutschler, W. (2005). [Evidence based diagnostic procedures for the determination of suspected blunt cervical spine injuries. Development of an algorithm]. *Der Unfallchirurg, 108*(11), 905. http://search.ebscohost.com/login.aspx?direct=true&db=cmedm&AN=15999250&site=ehost-live

Levin, K. A. (2006). Study design IV: cohort studies. *Evidence-based dentistry, 7*(2), 51-52.

Levy, L., Makarawo, S., Madzivire, D., Bhebhe, E., Verbeek, N., & Parry, O. (1998). Problems, struggles and some success with spinal cord injury in Zimbabwe. *Spinal Cord, 36*(3), 213-218.

Lewis, N. E., Tabarestani, T. Q., Cellini, B. R., Zhang, N., Marrotte, E. J., Wang, H., Laskowitz, D. T., Abd-El-Barr, M. M., & Faw, T. D. (2022). Effect of acute physical interventions on pathophysiology and recovery after spinal cord injury: a comprehensive review of the literature. *Neurospine, 19*(3), 671-686.

Li, L., Ye, W., Ruan, H., Yang, B., & Zhang, S. (2013). Impact of hydrophilic catheters on urinary tract infections in people with spinal cord injury: systematic review and meta-analysis of randomized controlled trials. *Archives of Physical Medicine and Rehabilitation, 94*(4), 782-787.

Lidal, I. B., Snekkevik, H., Aamodt, G., Hjeltnes, N., Stanghelle, J. K., & Biering-Sørensen, F. (2007). Mortality after spinal cord injury in Norway. *Journal of rehabilitation medicine, 39*(2), 145-151.

Löfvenmark, I., Norrbrink, C., Nilsson-Wikmar, L., Hultling, C., Chakandinakira, S., & Hasselberg, M. (2015). Traumatic spinal cord injury in Botswana: characteristics, aetiology and mortality. *Spinal Cord, 53*(2), 150-154.

Ma, Y., Zhang, L., & Boswell, M. (2016). Inequities in the allocation of medical resources in China's Township Health Centers. *China Agricultural Economic Review*.

Madasa, V., Boggenpoel, B., Phillips, J., & Joseph, C. (2020). Mortality and secondary complications four years after traumatic spinal cord injury in Cape Town, South Africa. *Spinal Cord Series and Cases, 6*(1), 1-7.

Magogo, J., Lazaro, A., Mango, M., Zuckerman, S. L., Leidinger, A., Msuya, S., Rutabasibwa, N., Shabani, H. K., & Härtl, R. (2021). Operative treatment of traumatic spinal injuries in Tanzania: surgical management, neurologic outcomes, and time to surgery. *Global spine journal, 11*(1), 89-98.

Maharaj, M., Stanford, R., Lee, B., Mobbs, R., Marial, O., Schiller, M., & Toson, B. (2017). The effects of early or direct admission to a specialised spinal injury unit on outcomes after acute traumatic spinal cord injury. *Spinal Cord, 55*(5), 518-524.

Majdan, M., Plancikova, D., Nemcovska, E., Krajcovicova, L., Brazinova, A., & Rusnak, M. (2017). Mortality due to traumatic spinal cord injuries in Europe: a cross-sectional and pooled analysis of population-wide data from 22 countries. *Scandinavian journal of trauma, resuscitation and emergency medicine, 25*(1), 64.

Malekzadeh, H., Golpayegani, M., Ghodsi, Z., Sadeghi-Naini, M., Asgardoon, M., Baigi, V., Vaccaro, A. R., & Rahimi-Movaghar, V. (2022). Direct cost of illness for spinal cord injury: a systematic review. *Global spine journal, 12*(6), 1267-1281.

Maphumulo, W. T., & Bhengu, B. R. (2019). Challenges of quality improvement in the healthcare of South Africa post-apartheid: A critical review. *Curationis, 42*(1), 1-9.

Marino, R. J., Jones, L., Kirshblum, S., Tal, J., & Dasgupta, A. (2008). Reliability and repeatability of the motor and sensory examination of the international standards for neurological classification of spinal cord injury. *The journal of spinal cord medicine, 31*(2), 166-170.

Marutha, N., & Ngoepe, M. (2017). The role of medical records in the provision of public healthcare services in the Limpopo province of South Africa. *South African Journal of Information Management, 19*(1), 1-8.

Mashola, M. K., Olorunju, S., & Mothabeng, J. (2019). Factors related to hospital readmissions in people with spinal cord injury in South Africa. *South African Medical Journal, 109*(2), 107-111.

Maynard, F. M., Bracken, M. B., Creasey, G., Donovan, W. H., Ducker, T. B., Garber, S. L., Marino, R. J., Stover, S. L., Tator, C. H., & Waters, R. L. (1997). International standards for neurological and functional classification of spinal cord injury. *Spinal Cord, 35*(5), 266-274.

Mccoll, M. A., Walker, J., Stirling, P., Wilkins, R., & Corey, P. (1997). Expectations of life and health among spinal cord injured adults. *Spinal Cord, 35*(12), 818-828.

Mcgee, A., Levitt, E. B., Prather, J. C., Crowther, D., Mcgwin, G., & Theiss, S. (2022). Association of Mortality and Charlson Comorbidity Index in Surgical Spinal Trauma Patients at a Level I Academic Center. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons*, 10.5435.

Mcgrath, R., Hall, O., Peterson, M., Devivo, M., Heinemann, A., & Kalpakjian, C. (2019). The association between the etiology of a spinal cord injury and time to mortality in the United States: A 44-year investigation. *The journal of spinal cord medicine, 42*(4), 444-452.

Mckinley, W., Meade, M. A., Kirshblum, S., & Barnard, B. (2004). Outcomes of early surgical management versus late or no surgical intervention after acute spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 85*(11), 1818-1825.

Mckinley, W. O., Jackson, A. B., Cardenas, D. D., & Michael, J. (1999). Long-term medical complications after traumatic spinal cord injury: a regional model systems analysis. *Archives of Physical Medicine and Rehabilitation, 80*(11), 1402-1410.

Mclaren, Z. M., Ardington, C., & Leibbrandt, M. (2014). Distance decay and persistent health care disparities in South Africa. *BMC Health Services Research, 14*(1), 1-9.

Meade, M. A., Trumpower, B., Forchheimer, M., & Diponio, L. (2016). Development and feasibility of health mechanics: a self-management program for individuals with spinal cord injury. *Topics in Spinal Cord Injury Rehabilitation, 22*(2), 121-134.

Merritt, C. H., Taylor, M. A., Yelton, C. J., & Ray, S. K. (2019). Economic impact of traumatic spinal cord injuries in the United States. *Neuroimmunology and neuroinflammation, 6*.

Michael, J., Krause, J. S., & Lammertse, D. P. (1999). Recent trends in mortality and causes of death among persons with spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 80*(11), 1411-1419.

Miseer, S., Mann, T., & Davis, J. H. (2019). Burden and profile of spinal pathology at a major tertiary hospital in the Western Cape, South Africa. *SA Orthopaedic Journal, 18*(1), 33-39.

Mitchell, P. H., Ferketich, S., Jennings, B. M., & Care, A. a. O. N. E. P. O. Q. H. (1998). Quality health outcomes model. *Image: The Journal of Nursing Scholarship, 30*(1), 43-46.

Mitiku, H., Weldegebreal, F., & Teklemariam, Z. (2015). Magnitude of opportunistic infections and associated factors in HIV-infected adults on antiretroviral therapy in eastern Ethiopia. *Hiv/aids (Auckland, NZ), 7*, 137.

Mohideen, M., Potgieter, M., Davis, J., & Badenhorst, D. (2019). Closed traction reduction of cervical spine facet dislocations: Compelled by law. *South African Medical Journal, 109*(11), 854-858.

Monaghan, T. F., Rahman, S. N., Agudelo, C. W., Wein, A. J., Lazar, J. M., Everaert, K., & Dmochowski, R. R. (2021). Foundational statistical principles in medical research: sensitivity, specificity, positive predictive value, and negative predictive value. *Medicina, 57*(5), 503.

Mortenson, W. B., Mills, P. B., Adams, J., Singh, G., Macgillivray, M., & Sawatzky, B. (2018). Improving self-management skills among people with spinal cord injury: Protocol for a mixed-methods study. *JMIR research protocols, 7*(11), e11069.

Moshi, H., Sundelin, G., Sahlen, K.-G., & Sörlin, A. (2017). Traumatic spinal cord injury in the north-east Tanzania–describing incidence, etiology and clinical outcomes retrospectively. *Global health action, 10*(1), 1355604.

Moshi, H. I., Sundelin, G. G., Sahlen, K. G., & Sörlin, A. V. (2021). A one-year prospective study on the occurrence of traumatic spinal cord injury and clinical complications during hospitalisation in North-East Tanzania. *African Health Sciences, 21*(2), 788-794.

Mutschler, W., Mutschler, M., Graw, M., & Lefering, R. (2016). Long-term survival after severe trauma [Article]. *Unfallchirurg, 119*(7), 546-553. https://doi.org/10.1007/s00113-016-0185-1

Naidoo, R., & Naidoo, K. (2021). Prioritising 'already-scarce'intensive care unit resources in the midst of COVID-19: a call for regional triage committees in South Africa. *BMC Medical Ethics, 22*(1), 1-9.

Naidoo, S. (2012). The South African national health insurance: a revolution in health-care delivery! *Journal of Public Health, 34*(1), 149-150.

Naledi, T., Barron, P., & Schneider, H. (2011). Primary health care in SA since 1994 and implications of the new vision for PHC re-engineering. *South African health review, 2011*(1), 17-28.

Nas, K., Yazmalar, L., Şah, V., Aydın, A., & Öneş, K. (2015). Rehabilitation of spinal cord injuries. *World journal of orthopedics, 6*(1), 8.

Netshisaulu, K. G., Malelelo-Ndou, H., & Ramathuba, D. U. (2019). Challenges experienced by health care professionals working in resource-poor intensive care settings in the Limpopo province of South Africa. *Curationis, 42*(1), 1-8.

Neumann, C. R., Brasil, A. V., & Albers, F. (2009). Risk factors for mortality in traumatic cervical spinal cord injury: Brazilian data. *Journal of Trauma, 67*(1), 67-70. https://doi.org/10.1097/TA.0b013e3181aa63f3

Noordzij, M., Dekker, F. W., Zoccali, C., & Jager, K. J. (2010). Measures of disease frequency: prevalence and incidence. *Nephron Clinical Practice, 115*(1), c17-c20.

Øderud, T. (2014). Surviving spinal cord injury in low income countries. *African Journal of Disability, 3*(2).

Osterthun, R., Post, M. W., Van Asbeck, F., Van Leeuwen, C., & Van Koppenhagen, C. (2014). Causes of death following spinal cord injury during inpatient rehabilitation and the first five years after discharge. A Dutch cohort study. *Spinal Cord, 52*(6), 483-488.

Palmer, C. (2007). Major trauma and the injury severity score-where should we set the bar? Annual Proceedings/Association for the Advancement of Automotive Medicine,

Parent, S., Barchi, S., Lebreton, M., Casha, S., & Fehlings, M. G. (2011). The impact of specialized centers of care for spinal cord injury on length of stay, complications, and mortality: a systematic review of the literature. *Journal of neurotrauma, 28*(8), 1363-1370.

Park, Y. S., Konge, L., & Artino, A. R. (2020). The positivism paradigm of research. *Academic Medicine, 95*(5), 690-694.

Paulus-Mokgachane, T. M., Visagie, S. J., & Mji, G. (2019). Access to primary care for persons with spinal cord injuries in the greater Gaborone area, Botswana. *African Journal of Disability, 8*(1), 1-9.

Peacock, W., * Shrosbree, Rd**, & Key, A. (1977). A review of 450 stabwounds of the spinal cord. *South African Medical Journal, 51*(26), 961-964.

Pentland, W., Walker, J., Minnes, P., Tremblay, M., Brouwer, B., & Gould, M. (2002). Women with spinal cord injury and the impact of aging. *Spinal Cord, 40*(8), 374-387.

Pilusa, S., Myezwa, H., & Potterton, J. (2021). Exploring prevention and management of secondary health conditions in people with spinal cord injury in South Africa. *International Journal of Therapy And Rehabilitation, 28*(12), 1-10.

Popowich Sheldon, A., Renwick, R., & Yoshida, K. K. (2011). Exploring body image and self-concept of men with acquired spinal cord injuries. *American Journal of Men's Health, 5*(4), 306-317.

Porta, M., Greenland, S., Hernán, M., Dos Santos Silva, I., & Last, J. (2008). A Dictionary of Epidemiology. Oxford University Press. *New York*.

Post, M. W., Nooijen, C. F., Postma, K., Dekkers, J., Penninx, F., Van Den Berg-Emons, R. J., & Stam, H. J. (2017a). People with spinal cord injury in the Netherlands. *American journal of physical medicine & rehabilitation, 96*(2), S93-S95.

Post, M. W., Nooijen, C. F., Postma, K., Dekkers, J., Penninx, F., Van Den Berg-Emons, R. J., & Stam, H. J. (2017b, Feb). People with Spinal Cord Injury in the Netherlands. *Am J Phys Med Rehabil, 96*(2 Suppl 1), S93-S95. https://doi.org/10.1097/PHM.0000000000000619

Quick, J., & Hall, S. (2015). Part three: The quantitative approach. *Journal of perioperative Practice, 25*(10), 192-196.

Rabadi, M. H., Mayanna, S. K., & Vincent, A. S. (2013). Predictors of mortality in veterans with traumatic spinal cord injury. *Spinal Cord, 51*(10), 784-788. https://doi.org/10.1038/sc.2013.77

Rahimi-Movaghar, V., Sayyah, M. K., Akbari, H., Khorramirouz, R., Rasouli, M. R., Moradi-Lakeh, M., Shokraneh, F., & Vaccaro, A. R. (2013). Epidemiology of traumatic spinal cord injury in developing countries: a systematic review. *Neuroepidemiology, 41*(2), 65-85. https://doi.org/10.1159/000350710

Ranganathan, P., & Aggarwal, R. (2018). Study designs: Part 1–An overview and classification. *Perspectives in clinical research, 9*(4), 184.

Ranganathan, P., Pramesh, C., & Buyse, M. (2015). Common pitfalls in statistical analysis: Clinical versus statistical significance. *Perspectives in clinical research, 6*(3), 169.

Reilly, B. M., & Evans, A. T. (2006). Translating clinical research into clinical practice: impact of using prediction rules to make decisions. *Annals of internal medicine, 144*(3), 201-209.

Reyes, A. A., Hurlbert, R. J., Dumont, T. M., & Ramey, W. L. (2022). The Number of Organ System Injuries Is a Predictor of Intrahospital Mortality in Complete Cervical Spinal Cord Injury. *World Neurosurgery, 158*, e788-e792.

Richard-Denis, A., Feldman, D., Thompson, C., & Mac-Thiong, J.-M. (2018). Prediction of functional recovery six months following traumatic spinal cord injury during acute care hospitalization. *The journal of spinal cord medicine, 41*(3), 309-317.

Richards, C., Mackenzie, N., Roberts, S., & Escorpizo, R. (2017, Feb). People with Spinal Cord Injury in the United States. *Am J Phys Med Rehabil, 96*(2 Suppl 1), S124-S126. https://doi.org/10.1097/PHM.0000000000000620

Rojas-García, A., Turner, S., Pizzo, E., Hudson, E., Thomas, J., & Raine, R. (2018). Impact and experiences of delayed discharge: A mixed-studies systematic review. *Health Expectations, 21*(1), 41-56.

Sabre, L., Rekand, T., Asser, T., & Korv, J. (2013, Nov). Mortality and causes of death after traumatic spinal cord injury in Estonia. *J Spinal Cord Med, 36*(6), 687-694. https://doi.org/10.1179/2045772313Y.0000000120

Salameh, A., Al Mohajer, M., & Daroucihe, R. O. (2015). Prevention of urinary tract infections in patients with spinal cord injury. *Cmaj, 187*(11), 807-811.

Savic, G., Bergström, E., Frankel, H., Jamous, M., & Jones, P. (2007). Inter-rater reliability of motor and sensory examinations performed according to American Spinal Injury Association standards. *Spinal Cord, 45*(6), 444-451.

Savic, G., Devivo, M., Frankel, H., Jamous, M., Soni, B., & Charlifue, S. (2017). Long-term survival after traumatic spinal cord injury: a 70-year British study. *Spinal Cord, 55*(7), 651-658.

Schmidt, O. I., Gahr, R. H., Gosse, A., & Heyde, C. E. (2009). ATLS® and damage control in spine trauma. *World Journal of Emergency Surgery, 4*(1), 1-11.

Scivoletto, G., Morganti, B., & Molinari, M. (2005). Early versus delayed inpatient spinal cord injury rehabilitation: an Italian study. *Archives of Physical Medicine and Rehabilitation, 86*(3), 512-516.

Senekal, A., & Vincent-Lambert, C. (2021). Experiences of emergency care providers conducting critical care transfers in Gauteng Province, South Africa. *Southern African Journal of Critical Care (Online), 37*(3), 92-96.

Shao, J., Zhu, W., Chen, X., Jia, L., Song, D., Zhou, X., Yan, W., & Zhang, Y. (2011). Factors associated with early mortality after cervical spinal cord injury. *The journal of spinal cord medicine, 34*(6), 555-562.

Shibahashi, K., Nishida, M., Okura, Y., & Hamabe, Y. (2019). Epidemiological State, Predictors of Early Mortality, and Predictive Models for Traumatic Spinal Cord Injury: A Multicenter Nationwide Cohort Study. *Spine (03622436), 44*(7), 479-487. https://doi.org/10.1097/BRS.0000000000002871

Shiferaw, W. S., Akalu, T. Y., Mulugeta, H., & Aynalem, Y. A. (2020). The global burden of pressure ulcers among patients with spinal cord injury: a systematic review and meta-analysis. *BMC musculoskeletal disorders, 21*(1), 1-11.

Shmueli, G. (2010). To explain or to predict? *Statistical science, 25*(3), 289-310.

Siddique, S. M., Tipton, K., Leas, B., Greysen, S. R., Mull, N. K., Lane-Fall, M., Mcshea, K., & Tsou, A. Y. (2021). Interventions to reduce hospital length of stay in high-risk populations: A systematic review. *JAMA network open, 4*(9), e2125846-e2125846.

Simpson, B., Villeneuve, M., & Clifton, S. (2022). The experience and perspective of people with spinal cord injury about well-being interventions: A systematic review of qualitative studies. *Disability and rehabilitation, 44*(14), 3349-3363.

Singh, A., Tetreault, L., Kalsi-Ryan, S., Nouri, A., & Fehlings, M. G. (2014). Global prevalence and incidence of traumatic spinal cord injury. *Clin Epidemiol, 6*, 309-331. https://doi.org/10.2147/CLEP.S68889

[Record #541 is using a reference type undefined in this output style.]

Soden, R., Walsh, J., Middleton, J., Craven, M., Rutkowski, S., & Yeo, J. (2000). Causes of death after spinal cord injury. *Spinal Cord, 38*(10), 604-610.

Solomon, R. M., Dhakal, R., Halpin, S. J., Hariharan, R., O'connor, R. J., Allsop, M., & Sivan, M. (2022). Telerehabilitation for individuals with spinal cord injury in low-and middle-income countries: a systematic review of the literature. *Spinal Cord, 60*(5), 395-403.

Song, J. W., & Chung, K. C. (2010). Observational studies: cohort and case-control studies. *Plastic and reconstructive surgery, 126*(6), 2234.

Sothmann, J., Stander, J., Kruger, N., & Dunn, R. (2015). Epidemiology of acute spinal cord injuries in the Groote Schuur hospital acute spinal cord injury (GSH ASCI) unit, Cape Town, South Africa, over the past 11 years. *South African Medical Journal, 105*(10), 835-839.

Statistics South Africa. (2011). *City of Cape Town*. http://www.statssa.gov.za/?page_id=1021&id=city-of-cape-town-municipality

Stillman, M. D., Barber, J., Burns, S., Williams, S., & Hoffman, J. M. (2017). Complications of spinal cord injury over the first year after discharge from inpatient rehabilitation. *Archives of Physical Medicine and Rehabilitation, 98*(9), 1800-1805.

Strom, V., Manum, G., Leiulfsrud, A., Wedege, P., Rekand, T., Halvorsen, A., Fjellheim, L. A., & Stanghelle, J. K. (2017, Feb). People with Spinal Cord Injury in Norway. *Am J Phys Med Rehabil, 96*(2 Suppl 1), S99-S101. https://doi.org/10.1097/PHM.0000000000000572

Sumida, M., Fujimoto, M., Tokuhiro, A., Tominaga, T., Magara, A., & Uchida, R. (2001). Early rehabilitation effect for traumatic spinal cord injury. *Archives of Physical Medicine and Rehabilitation, 82*(3), 391-395.

Sutton, R. T., Pincock, D., Baumgart, D. C., Sadowski, D. C., Fedorak, R. N., & Kroeker, K. I. (2020). An overview of clinical decision support systems: benefits, risks, and strategies for success. *NPJ digital medicine, 3*(1), 1-10.

Swift, A., Heale, R., & Twycross, A. (2020). What are sensitivity and specificity? *Evidence-Based Nursing, 23*(1), 2-4.

Takemura, S., Sasai, K., Ohnari, H., Ichikawa, N., Akagi, S., & Iida, H. (2006). Brown–Sequard-plus syndrome due to stab injury: a case report. *Spinal Cord, 44*(8), 518-521.

Tamás, V., Kocsor, F., Gyuris, P., Kovács, N., Czeiter, E., & Büki, A. (2019). The young male syndrome—An analysis of sex, age, risk taking and mortality in patients with severe traumatic brain injuries. *Frontiers in neurology, 10*, 366.

Teague, S., Youssef, G. J., Macdonald, J. A., Sciberras, E., Shatte, A., Fuller-Tyszkiewicz, M., Greenwood, C., Mcintosh, J., Olsson, C. A., & Hutchinson, D. (2018). Retention strategies in longitudinal cohort studies: a systematic review and meta-analysis. *BMC medical research methodology, 18*(1), 1-22.

Tee, J. W., Chan, P. C., Gruen, R. L., Fitzgerald, M. C., Liew, S. M., Cameron, P. A., & Rosenfeld, J. V. (2013). Early predictors of mortality after spine trauma: a level 1 Australian trauma center study. *Spine, 38*(2), 169-177.

Ter Wengel, P., Feller, R., Stadhouder, A., Verbaan, D., Oner, F., Goslings, J., & Vandertop, W. (2018). Timing of surgery in traumatic spinal cord injury: a national, multidisciplinary survey. *European Spine Journal, 27*(8), 1831-1838.

Tooth, L., Mckenna, K., & Geraghty, T. (2003). Rehabilitation outcomes in traumatic spinal cord injury in Australia: functional status, length of stay and discharge setting. *Spinal Cord, 41*(4), 220-230.

Torres, A., Niederman, M. S., Chastre, J., Ewig, S., Fernandez-Vandellos, P., Hanberger, H., Kollef, M., Bassi, G. L., Luna, C. M., & Martin-Loeches, I. (2018). Summary of the international clinical guidelines for the management of hospital-acquired and ventilator-acquired pneumonia. *ERJ open research, 4*(2).

Tricco, A. C., Antony, J., Zarin, W., Strifler, L., Ghassemi, M., Ivory, J., Perrier, L., Hutton, B., Moher, D., & Straus, S. E. (2015). A scoping review of rapid review methods. *BMC medicine, 13*(1), 224.

Tricco, A. C., Langlois, E., Straus, S. E., & Organization, W. H. (2017). *Rapid reviews to strengthen health policy and systems: a practical guide*. World Health Organization.

Uk National Clinical Guideline Centre. (2016). Spinal Injury: Assessment and Initial Management.

Vaillancourt, C., Charette, M., Kasaboski, A., Maloney, J., Wells, G. A., & Stiell, I. G. (2011, 2011 Feb). Evaluation of the safety of C-spine clearance by paramedics: design and methodology. *BMC emergency medicine, 11*, 1-1. https://doi.org/10.1186/1471-227x-11-1

Van Den Berg, M. E., Castellote, J. M., De Pedro-Cuesta, J., & Mahillo-Fernandez, I. (2010, Aug). Survival after spinal cord injury: a systematic review. *J Neurotrauma, 27*(8), 1517-1528. https://doi.org/10.1089/neu.2009.1138

Van Middendorp, J. J., Hosman, A. J., Donders, A. R. T., Pouw, M. H., Ditunno Jr, J. F., Curt, A., Geurts, A. C., Van De Meent, H., & Group, E.-S. S. (2011). A clinical prediction rule for ambulation outcomes after traumatic spinal cord injury: a longitudinal cohort study. *The Lancet, 377*(9770), 1004-1010.

Van Weert, K., Schouten, E. J., Hofstede, J., Van De Meent, H., Holtslag, H. R., & Van Den Berg-Emons, R. J. (2014). Acute phase complications following traumatic spinal cord injury in Dutch level 1 trauma centres. *Journal of rehabilitation medicine, 46*(9), 882-885.

Varma, A., Hill, E. G., Nicholas, J., & Selassie, A. (2010). Predictors of early mortality after traumatic spinal cord injury: a population-based study. *Spine, 35*(7), 778-783.

Velmahos, G., Degiannis, E., Hart, K., Souter, I., & Saadia, R. (1995). Changing profiles in spinal cord injuries and risk factors influencing recovery after penetrating injuries. *Journal of Trauma and Acute Care Surgery, 38*(3), 334-337.

[Record #820 is using a reference type undefined in this output style.]

Wahman, K., Chlaidze, G., & Joseph, C. (2019). Secondary medical complications after traumatic spinal cord injury in Stockholm, Sweden: Towards developing prevention strategies. *Journal of rehabilitation medicine, 51*(7), 513-517.

Walters, B. C., Hadley, M. N., Hurlbert, R. J., Aarabi, B., Dhall, S. S., Gelb, D. E., Harrigan, M. R., Rozelle, C. J., Ryken, T. C., & Theodore, N. (2013). Guidelines for the management of acute cervical spine and spinal cord injuries: 2013 update. *Neurosurgery, 60*(CN_suppl_1), 82-91.

Wen, H., Devivo, M. J., Heinemann, A. W., Krause, J. S., Robinson-Whelen, S., & Chen, Y. (2022). Mortality Beyond the First Year After Spinal Cord Injury: Does Body Mass Index Matter? *Archives of Physical Medicine and Rehabilitation, 103*(4), 711-721.

Wen, H., Devivo, M. J., Mehta, T., Kaur Baidwan, N., & Chen, Y. (2021). The impact of body mass index on one-year mortality after spinal cord injury. *The journal of spinal cord medicine, 44*(4), 563-571.

White, B. A., Dea, N., Street, J. T., Cheng, C. L., Rivers, C. S., Attabib, N., Kwon, B. K., Fisher, C. G., & Dvorak, M. F. (2017). The economic burden of urinary tract infection and pressure ulceration in acute traumatic spinal cord injury admissions: evidence for comparative economics and decision analytics from a matched case-control study. *Journal of neurotrauma, 34*(20), 2892-2900.

Wilson, J. R., Cadotte, D. W., & Fehlings, M. G. (2012). Clinical predictors of neurological outcome, functional status, and survival after traumatic spinal cord injury: a systematic review. *Journal of Neurosurgery: Spine, 17*, 11-26. https://doi.org/10.3171/2012.4.AOSPINE1245

Wilson, J. R., Grossman, R. G., Frankowski, R. F., Kiss, A., Davis, A. M., Kulkarni, A. V., Harrop, J. S., Aarabi, B., Vaccaro, A., & Tator, C. H. (2012). A clinical prediction model for long-term functional outcome after traumatic spinal cord injury based on acute clinical and imaging factors. *Journal of neurotrauma, 29*(13), 2263-2271.

Workman, M., & Kruger, N. (2019). A survey of the use of traction for the reduction of cervical dislocations. *SA Orthopaedic Journal, 18*(2), 25-30.

World Health Organization. (1946). International health conference. *New York, 19*.

Wyndaele, M., & Wyndaele, J. J. (2006, Sep). Incidence, prevalence and epidemiology of spinal cord injury: what learns a worldwide literature survey? *Spinal Cord, 44*(9), 523-529. https://doi.org/10.1038/sj.sc.3101893

Xi, M., Elterman, D. S., Welk, B., Pakosh, M., & Chan, B. C. (2021). Cost-effectiveness of hydrophilic-coated urinary catheters for individuals with spinal cord injury: a systematic review. *BJUI compass, 2*(2), 71-81.

Yeo, J. D., Walsh, J., Rutkowski, S., Soden, R., Craven, M., & Middleton, J. (1998). Mortality following spinal cord injury. *Spinal Cord, 36*(5), 329-336.

Yohann, A., Kayange, L., Purcell, L. N., Gallaher, J., & Charles, A. (2022). Direct Transfer to a Tertiary Care Hospital After Traumatic Injury is Associated with a Survival Benefit in a Resource-Limited Setting. *World journal of surgery*, 1-8.

Yohann, A., Kratzke, I., Williams, B., & Charles, A. (2021). The effect of transfer status on trauma outcomes in low-and middle-income countries: A systematic review and meta-analysis. *Injury*.

Yousefifard, M., Rahimi, M. V., Baikpour, M., Ghelichkhani, P., Hosseini, M., Moghadas, J. A., Aziznejad, H., & Tafakhori, A. (2017). EARLY VERSUS LATE DECOMPRESSION FOR TRAUMATIC SPINAL CORD INJURIES; A SYSTEMATIC REVIEW ANDMETA-ANALYSIS.

Zakrasek, E., Creasey, G., & Crew, J. (2015). Pressure ulcers in people with spinal cord injury in developing nations. *Spinal Cord, 53*(1), 7-13.

Appendix 1 Ethics letter from the University of the Western Cape (Larger study)

UNIVERSITY of the WESTERN CAPE

OFFICE OF THE DIRECTOR: RESEARCH
RESEARCH AND INNOVATION DIVISION

Private Bag X17, Bellville 7535
South Africa
T: +27 21 959 2988/2948
F: +27 21 959 3170
E: research-ethics@uwc.ac.za
www.uwc.ac.za

24 October 2016

Dr C Joseph
Physiotherapy
Faculty of Community and Health Sciences

Ethics Reference Number: BM/16/3/24

Project Title: Improving health systems for traumatic spinal cord injury in South Africa and Sweden: A novel investigation processes and outcomes.

Approval Period: 28 September 2016 to 28 September 2017

I hereby certify that the Biomedical Science Research Ethics Committee of the University of the Western Cape approved the scientific methodology and ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval. Please remember to submit a progress report in good time for annual renewal.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

PROVISIONAL REC NUMBER -130416-050

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix 2 Ethics letter from the University of the Western Cape (Current study)

UNIVERSITY of the WESTERN CAPE

OFFICE OF THE DIRECTOR: RESEARCH
RESEARCH AND INNOVATION DIVISION

Private Bag X17, Bellville 7535
South Africa
T: +27 21 959 4111/2948
F: +27 21 959 3170
E: research-ethics@uwc.ac.za
www.uwc.ac.za

25 September 2018

Mr B Boggenpoel
Physiotherapy
Faculty of Community and Health Sciences

Ethics Reference Number: BM18/1/17

Project Title: The development of a health care decision making model to improve survival of persons with traumatic spinal cord injuries (tSCI).

Approval Period: 21 September 2018 – 21 September 2019

I hereby certify that the Biomedical Science Research Ethics Committee of the University of the Western Cape approved the scientific methodology and ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report in good time for annual renewal.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

PROVISIONAL REC NUMBER - 130416-050

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix 3 Ethics letter from Groote Schuur Hospital

Western Cape Government
Health

GROOTE SCHUUR HOSPITAL
Enquiries: Dr Bernadette Eick
E-mail : Bernadette.Eick@westerncape.gov.za

Dr Conran Joseph
University of the Western Cape
Physiotherapy Department
BELLVILLE

E-mail: Conran.Joseph@gmail.com

Dear Dr Joseph,

RESEARCH PROJECT: Improving Health Systems For Traumatic Spinal Cord Injury In South Africa and Sweden: A Novel Investigation Process and Outcomes

Your recent letter to the hospital refers.

You are hereby granted permission to proceed with your research which is valid until **28 September 2017.**

Please note the following:

a) Your research may not interfere with normal patient care.
b) Hospital staff may not be asked to assist with the research.
c) No additional costs to the hospital should be incurred i.e. Lab, consumables or stationary.
d) **No patient folders may be removed from the premises or be inaccessible.**
e) Please provide the research assistant/field worker with a copy of this letter as verification of approval.
f) Confidentiality must be maintained at all times.
g) Should you at any time require photographs of your subjects, please obtain the necessary indemnity forms from our Public Relations Office (E45 OMB or ext. 2187/2188).
h) Should you require additional research time beyond the stipulated expiry date, please apply for an extension.
i) Please discuss the study with the HOD before commencing.
j) Please introduce yourself to the person in charge of an area before commencing.
k) On completion of your research, please forward any recommendations/findings that can be beneficial to use to take further action that may inform redevelopment of future policy / review guidelines.
l) **Kindly submit a copy of the publication or report to this office on completion of the research.**

I would like to wish you every success with the project.

Yours sincerely

DR BERNADETTE EICK
CHIEF OPERATIONAL OFFICER
Date: 11 January 2017

C.C. Mr L. Naidoo, Ms C. Davids, Professor R. Dunn

G46 Management Suite, Old Main Building,
Observatory 7925

Private Bag X,
Observatory, 7935

Tel: +27 21 404 6288 fax: +27 21 404 6125

www.capegateway.go.v.za

Appendix 4 English consent form

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21-959 2343

E-mail: bboggenpoel@uwc.ac.za

Title of research project:

The development of a health care decision making model to improve survival of persons with traumatic spinal cord injuries (tSCI).

The study has been described to me in language that I understand. My questions about the study have been answered. I understand what my participation will involve and I agree to participate of my own choice and free will. I understand that my identity will not be disclosed to anyone. I understand that I may withdraw from the study at any time without giving a reason and without a fear of negative consequences or loss of benefits. This research project involves making audiotapes of you. The audiotapes will be made to keep track of participants that potentially need to provide verbal consent. The researcher and his supervisor will have access to these audiotapes and they will be kept on a password protected laptop and discarded after five years.

___ I agree to be audiotaped during my participation in this study.

___ I do not agree to be audiotaped during my participation in this study.

Participant's name…………………………..

Participant's signature………………………………….

Date……………………….

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

Supervisor: Dr Conran Joseph

Tel: +27219592542

Email: cjoseph@uwc.ac.za

UNIVERSITY of the WESTERN CAPE

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix 5 Afrikaans consent form

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

TOESTEMMINGS VORM

Titel van narvorsingprojek:
Die ontwikkeling van 'n gesondheidsorg besluitneming model om oorlewing te verbeter van persone met traumatiese rugmurg beserings.

Die studie is al beskryf vir my in n taal wat ek verstaan. My vrae oor die studie is beantwoord. Ek verstaan wat my deelname sal betrek en ek stem saam om deel te neem van my eie keuse en vrye wil. Ek verstaan dat my identiteit nie aan enigiemand bekend gemaak sal word. Ek verstaan dat ek kan trek uit die studie te eniger tyd sonder om 'n rede en sonder vrees vir negatiewe gevolge of verlies van voordele. Die gebruik van oudiobande sal gemaak word vir daai persone wat mondelinge toestemming benodig. Die navorser en sy toesighouer sal toegang he aan hierdie oudio-bande en dit sal vir vyf jaar op 'n wagwoord beskermde skootrekenaar gehou word. Na vyf jaar sal die narvorser ontslae raak van die oudio-bande.

___ Ek stem in om tydens my deelname aan hierdie studie gehoor te gee.

___ Ek stem nie saam om tydens my deelname aan hierdie studie gehoor te kry nie.

Deelnemer se naam ……………………….

Deelnemer se handtekening ……………………………….

Datum ……………………..

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

Supervisor: Dr Conran Joseph
Tel: +27219592542
Email: cjoseph@uwc.ac.za

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix 6 isiXhosa consent form

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2342
E-mail: bboggenpoel@uwc.ac.za

IFOMU YESIVUMELWANO

Isihloko sophando lweprojekthi:
Ukuqulunqwa komkhomba-ndlela wokuthabatha izigqibo ngonakekelo lwezempilo ukuphucula ukuphila kwabantu abanomonzakalo womnqonqo ngokwengozi.

Uphando luye lachazwa kum ngolwimi endiluqondayo. Imibuzo yam malunga nolu phando sele iphendulwe. Ndiyayiqonda inxaxheba yam iya kubandakanya kwaye ndiyavuma ukuthabatha inxaxheba ngokokuthanda kwam yaye ndizinikezele. Ndiyaqonda ukuba iinkcukacha zam azizo kutyhilwa nakubani. Ndiyaqonda ukuba ndingarhoxa kwesi sifundo nanini ngaphandle kokunika isizathu nangaphandle koloyiko lweziqhamo ezimbi okanye ukulahlekelwa yinzuzo. Olu phando lwale projekthi lubandakanya ukwenza ushicelelo lwakho xa uthetha. Ngumthathi nxaxheba yedwa oyakufikelela kwisishiceleli, yaye ziyakuvalelwa kwikhompyutha enokhuseleko olwaziwa ngumshiceleli yedwa. Kuyakuthi emveni kweminyaka emihlanu zicinywe kwikhompyutha leyo.

___ Ndiyavuma ukushicelelwa ngethuba ndithatha inxaxheba kwesisifundo.

___ Andivumi ukushicelelwa ngethuba ndithatha inxaxheba kwesisifundo.

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2342
E-mail: bboggenpoel@uwc.ac.za

Igama lomthathi nxaxheba ....

Utyikityo lomthathi nxaxheba ....

Umhla ....

Supervisor: Dr Conran Joseph

Tel: +27219592542

Email: cjoseph@uwc.ac.za

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix 7 English participant information sheet

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

INFORMATION SHEET:

Project title: The development of a health care decision making model to improve survival of persons with traumatic spinal cord injuries (tSCI).

What is this study about?

Mr Blake Boggenpoel (PI) from the University of the Western Cape is conducting this research project. The purpose of the research project is to determine the mortality rate, functioning and processes of care of patients that have sustained a traumatic spinal cord injury, so as to improve aspects of the care being delivered, and to develop a healthcare decision making model to improve allocation of resources.

What does participation in this study entail?

You were asked to participate in this research project because you are an individual that has sustained a traumatic spinal cord injury. You will be asked to answer questions relating to general function, quality of life and some demographic information.

Would my participation in this study be kept confidential?

The researchers will undertake to protect your identity and the nature of your contribution. To ensure your anonymity, each participant will be allocated a specific record number and no reference will be made to your name at anytime. Only the lead researcher will have access to each record number of each participant. To ensure your confidentiality, all information gathered will be stored in a locked filing cabinet and a password protected laptop. No unauthorised parties will have access to your information in any way. If we write a report or an article about this research project, your identity will be protected.

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

In accordance with legal requirements and/or professional standards, we will disclose to the appropriate individuals and/or authorities information that comes to our attention concerning child abuse or neglect or potential harm to you or others. In this event, we will inform you that we have to break confidentiality to fulfil our legal responsibility to report to the designated authorities.

What are the risks of this research?

There may be some risks from participating in this research study. All human interactions and talking about self or others carry some amount of risks. We will nevertheless minimise such risks and act promptly to assist you if you experience any discomfort, psychological or otherwise during the process of your participation in this study. Where necessary, an appropriate referral will be made to a suitable professional for further assistance or intervention.

What are the benefits of this research?

On a personal level, you will gain an understanding of how the injury affected you and how you function in relation to others. It will also provide you with valuable information as to the factors that may improve your health outcomes and prevent readmissions. The results from this research will also allow for better management of patients in hospital and post discharge.

Do I have to be in this research and may I stop participating at any time?

Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

What if I have questions?

This research is being conducted by Mr Blake Boggenpoel at the University of the Western Cape. If you have any questions about the research study itself, please contact me at: work: 021 959 2343 or cell 082 582 9373, email bboggenpoel@uwc.ac.za.Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact:

Dr Nondwe Mlenzana
Head of Department: Physiotherapy
University of the Western Cape
Private Bag X17
Bellville 7535
nmlenzana@uwc.ac.za

Prof Anthea Rhoda
Dean of the Faculty of Community and Health Sciences
University of the Western Cape
Private Bag X17
Bellville 7535
chs-deansoffice@uwc.ac.za

BMREC
Robert Sobukwe Road
Bellville
Cape Town
7535
Tel: +27219592988
research-ethics@uwc.ac.za

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21-959 2343

E-mail: bboggenpoel@uwc.ac.za

Supervisor: Dr Conran Joseph

Tel: +27219592542

Email: cjoseph@uwc.ac.za

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix 8 Afrikaans participant information sheet

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2342
E-mail: bboggenpoel@uwc.ac.za

INLIGTINGSBLAD:

Projektitel: Die ontwikkeling van 'n gesondheidsorg besluitneming model om oorlewing te verbeter van persone met traumatiese rugmurg beserings.

Wat behels die studie?
Hierdie navorsingsprojek word deur mnr. Blake Boggenpoel (PI) van die Universiteit van Wes-Kaapland behartig. Die doel van die navorsing is om die sterftesyfer, funksionering en prosesse van versorging van pasiënte wat 'n traumatiese rugmurgbesering het, te bepaal, ten einde aspekte van versorging te verbeter en om 'n model vir gesondheidsorg-besluitneming te ontwikkel om die toewysing van hulpbronne te verbeter.

Wat behels betrokkenheid in hierdie studie?
U is gevra om in hierdie studie deel te neem omdat u 'n traumatiese rugmurgbesering opgedoen het. U sal gevra word om vrae te beantwoord aangaande u algemene funksionering, gehalte van lewe en sekere demografiese inligting.

Sal my betrokkenheid in hierdie studie vertroulik hanteer word?
Die navorsers sal onderneem om u identiteit en die aard van die u bydrae te beskerm. Om u anonimiteit te verseker, sal elke deelnemer 'n spesifieke rekordnommer toegeken word, en daar sal op geen stadium na u naam verwys word nie. Slegs die hoofnavorser sal toegang hê tot elke rekordnommer van elke deelnemer. Om u vertroulikheid te verseker, sal alle inligting wat ingesamel word, gestoor word in 'n geslote liasseringskas en 'n wagwoordbeskermde skootrekenaar. Geen ongemagtigde partye sal op enige manier toegang tot u inligting hê nie. As ons 'n verslag of 'n artikel oor hierdie navorsingsprojek skryf, sal u identiteit beskerm word.

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2342
E-mail: bboggenpoel@uwc.ac.za

In ooreenstemming met wetlike vereistes en/of professionele standaarde, sal ons aan die toepaslike individue en/of owerhede inligting bekend maak wat onder ons aandag kom oor kindermishandeling of verwaarlosing of potensiële skade aan u of ander. In hierdie geval sal ons u inlig dat ons u vertroulikheid moet breek om ons wettige verantwoordelikheid te vervul om aan die aangewese owerhede verslag te doen.

Wat is die risiko van betrokkenheid in hierdie studie?

Daar is sekere risiko's verbonde daaraan om deel te wees in hierdie studie. Alle menslike interaksie en om te praat oor jouself of ander mense dra 'n sekere mate van risiko. Ons sal egter poog om sulke risiko's te verminder en dadelik op te tree om u te help as u enige ongemak, sielkundige of andersins, sal ervaar tydens die proses van u deelname aan hierdie studie. Waar nodig, sal 'n gepaste verwysing na 'n geskikte professioneel vir verdere bystand of ingryping.

Wat is die voordele van hierdie navorsing?

Op 'n persoonlike vlak sal jy verstaan hoe die besering jou beïnvloed het en hoe om te funksioneer in verhouding met ander. Dit sal jou ook waardevolle inligting verskaf oor die faktore wat jou gesondheidsuitkomste kan verbeter en hertoelating kan voorkom. Die resultate van hierdie navorsing sal ook voorsiening maak vir beter bestuur van pasiënte in die hospitaal en na ontslag uit die hospitaal.

Moet ek in hierdie navorsing wees en mag ek op enige stadium ophou deelneem?

U deelname aan hierdie navorsing is heeltemal vrywillig. U mag kies om glad nie deel te neem nie. As u besluit om aan hierdie navorsing deel te neem, kan u enige tyd ontrek. Indien u besluit om nie aan hierdie studie deel te neem nie,

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2342
E-mail: bboggenpoel@uwc.ac.za

of as u op enige stadium ontrek, sal u nie gepenaliseer word, of enige voordele waarvoor u andersins kwalifiseer, verloor nie.

Wat as ek vrae het?

Hierdie navorsing word deur mnr. Blake Boggenpoel aan die Universiteit van Wes-Kaapland gedoen. As u vrae het oor die navorsingstudie self, kontak my gerus by: werk: 021 959 2343 of sel 082 582 9373, e-pos bboggenpoel@uwc.ac.za. Indien u enige vrae rakende hierdie studie en u regte as 'n navorsingsdeelnemer het, of as u enige probleme rakende die studie aangemeld het, kontak asseblief:

Dr Nondwe Mlenzana
Hoof van Departement: Fisioterapie
Universiteit van Wes-Kaapland
Privaatsak X17
Bellville 7535
nmlenzana@uwc.ac.za

Prof Anthea Rhoda
Dekaan van die Fakulteit Gemeenskaps- en Gesondheidswetenskappe
Universiteit van Wes-Kaapland
Privaatsak X17
Bellville 7535
chs-deansoffice@uwc.ac.za

Appendix 9 isiXhosa participant information sheet

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

IINKCUKACHA ZENGCACISO

Isihloko seProjekthi:
Ukuqulunqwa komkhomba-ndlela wokuthabatha izigqibo ngonakekelo lwezempilo ukuphucula ukuphila kwabantu abanomonzakalo womnqonqo ngokwengozi.

Yintoni esi sifundo?

Le projekthi yophando eyenziwa nguMnumzana Blake Boggenpoel (PI) ovela kwiDyunivesithi yeNtshona Koloni. Ndiyakumema ukuba uthathe inxaxheba kule projekthi yophando kuba ungumntu oye wanyamezela umonakalo womnqonqo wakho Injongo yale projekthi yophando kukuqonda ngezinga lokufa, ukusebenzisa amalungu omzimba kunye neenkqubo zokunyamekela kwezigulane eziye zenza umonakalo wokulimala komnqonqo, ukwenzela ukuba kuphuculwe iinkalo zokunyamekela, kunye nokuphuhlisa umgangatho wesigqibo sokhathalelo lwempilo ukuphucula nokwabiwa kwezibonelelo.

Ndiya kucelwa ukuba ndenze ntoni ukuba ndivuma ukuthatha inxaxheba?

Uya kucelwa ukuba uphendule imibuzo ephathelene nomsebenzi jikelele, umgangatho wobomi kunye nolwazi oluthile loluntu.

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

Ngaba ukuthatha inxaxheba kwam kulesi sifundo kuya kugcinwa ngasese?

Abaphandi baya kukhusela ubunjani bakho kunye nesimo senkxaso yakho. Ukuze uqinisekise ukuba ungaziwa, umntu othabatha inxaxheba uya kwabelwa inombolo ethile yerekhodi kwaye akukho sikhokelo esizakwenziwa kwigama lakho nanini na. Ngumphandi okhokela uphando kuphela oya kufumana inombolo yerekhodi yomntu ngamnye. Ukuqinisekisa imfihlo yakho, lonke ulwazi oluzakuqokelelwa luya kugcinwa kwikhabhinethi yokushicilela kunye nephasiwedi ekhuselweyo. Akukho maqela angagunyaziswanga aya kufumana ulwazi lwakho nangayiphi indlela. Ukuba sibhala ingxelo okanye sibhala inqaku malunga nale projekthi yophando, isazisi sakho siya kukhuselwa.

Ngokuhambelana neemfuno zomthetho kunye / okanye imigangatho yezobugcisa, siya kubhengeza kubantu abafanelekileyo kunye / okanye igunya lokufumana ulwazi malunga nokuxhaphazwa kwabantwana okanye ukunganakwa okanye ukulimala wena okanye abanye. Kulo mcimbi, siya kukuxelela ukuba kufuneka sidibanise imfihlo ukuze sizalise uxanduva lwethu lomthetho ukunika ingxelo kumagosa atyunjiweyo.

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

Ziziphi iingozi zolu phando?

Kukho ubungcipheko bokuthabatha inxaxheba kulo msebenzi wophando. Zonke iintsebenziswano zabantu kunye nokuthetha ngabanye okanye abanye bathatha inxalenye yengozi. Kodwa siya kunciphisa ingozi enjalo kwaye senze ngokukhawuleza ukukunceda ukuba uva ungakhululekanga, unophazamiseko lwengqondo okanye ngenye indlela ngexesha lokuthatha inxaxheba kulolu phofu. Xa kuyimfuneko, ukuthunyelwa okufanelekileyo kuya kwenziwa kwicandelo elifanelekileyo lochwepheshe ukuze uncediswe okanye uncedwe.

Ziziphi iingenelo zolu phando?

Kwinqanaba lomntu, uya kuqonda ukuba ukulimala kukuchaphazele njani kunye nendlela osebenza ngayo ngokumalunga nabanye. Siyaku kunika ulwazi olubalulekileyo malunga nezinto ezinokuphucula iziphumo zempilo yakho kunye nokukhusela ukuphinda ubuyele esibhedlele. Iziphumo ezivela kulo phando ziya kuvumela ukuba kubekho ukulungiswa kolawulo lwezigulane esibhedlele kunye nokulawula emveni kokukhutshwa esibhedlele.

Ngaba kufuneka ndibe koluphando kwaye ndivumelekile ukuyeka ukuthatha inxaxheba nanini na?

Ukuthatha inxaxheba kwakho kolu phando kukuzithandela ngokupheleleyo. Unokukhetha ukuba ungathathi nxaxheba konke- konke. Ukuba uthatha

UNIVERSITY of the WESTERN CAPE

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

isigqibo sokuthatha inxaxheba kolu phando, unokuyeka ukuthatha inxaxheba nanini na. Ukuba uthatha isigqibo sokuba ungathathi nxaxheba kwesi sifundo okanye ukuba unqamle ukuthatha inxaxheba nangaliphi na ixesha, awuyi kuhlawulwa okanye ulahlekelwe nayiphi na inzuzo apho ufanelekile uyifumane.

Kuthekani ukuba ndinemibuzo?

Olu phando luqhutywa nguMnumzana Blake Boggenpoel kwiYunivesithi yeNtshona Koloni. Ukuba unemibuzo malunga nophando olu, nceda uqhagamshelane nam: ku: 021 9592343 okanye iseli 0825829373, imeyile bboggenpoel@uwc.ac.za . Ukuba ngaba unayo nayiphi na imibuzo malunga nesi sifundo kunye namalungelo akho njengomthathi-nxaxheba okanye ukuba unqwenela ukubika nayiphi na ingxaki oye wahlangabezana nayo malunga nophando, nceda qhagamshelana:

Dr Nondwe Mlenzana

Head of Department: Physiotherapy

University of the Western Cape

Private Bag X17

Bellville 7535

nmlenzana@uwc.ac.za

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2343
E-mail: bboggenpoel@uwc.ac.za

Prof Anthea Rhoda

Dean of the Faculty of Community and Health Sciences

University of the Western Cape

Private Bag X17

Bellville 7535

chs-deansoffice@uwc.ac.za

BMREC

Robert Sobukwe Road

Bellville

Cape Town

7535

Tel: +27219592988

research-ethics@uwc.ac.za

Supervisor: Dr Conran Joseph

Tel: +27219592542

Email: cjoseph@uwc.ac.za

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix 10 ISCoS basic data set, Core Form

3

INTERNATIONAL SPINAL CORD INJURY DATA SET
CORE DATA SET COLLECTION FORM

Dates (YYYYMMDD)

Birth date __ __ __ __/ __ __/ __ __

Injury date __ __ __ __/ __ __/ __ __

Acute Admission __ __ __ __/ __ __/ __ __

Final Inpatient Discharge __ __ __ __/ __ __/ __ __

Total Days Hospitalized __ __ __ __

Gender ___

Injury Etiology ___ Vertebral Injury ___ Associated Injury ___

Spinal Surgery ___ Ventilatory Assistance ___ Place of Discharge ___

Neurological Data

Acute Admission	**Final Inpatient Discharge**
Date of Exam	Date of Exam
__ __ __ __/ __ __/ __ __	__ __ __ __/ __ __/ __ __
Sensory level Left Right	Sensory level Left Right
___ ___ ___ ___ ___ ___	___ ___ ___ ___ ___ ___
Motor level Left Right	Motor level Left Right
___ ___ ___ ___ ___ ___	___ ___ ___ ___ ___ ___
ASIA Impairment Scale	ASIA Impairment Scale
____	____

Appendix 11 American Spinal Cord Injury Association Impairment Scale (ASIA)

Patient Name ______________________________

Examiner Name ______________________________ Date/Time of Exam ____________________

AMERICAN SPINAL INJURY ASSOCIATION

STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

ISCoS

MOTOR

KEY MUSCLES
(scoring on reverse side)

	R	L	
C5			Elbow flexors
C6			Wrist extensors
C7			Elbow extensors
C8			Finger flexors (distal phalanx of middle finger)
T1			Finger abductors (little finger)

UPPER LIMB TOTAL ☐ + ☐ = ☐
(MAXIMUM) (25) (25) (50)

Comments:

	R	L	
L2			Hip flexors
L3			Knee extensors
L4			Ankle dorsiflexors
L5			Long toe extensors
S1			Ankle plantar flexors

Voluntary anal contraction (Yes/No) ☐

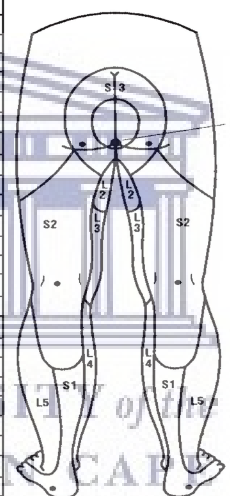
LOWER LIMB TOTAL ☐ + ☐ = ☐
(MAXIMUM) (25) (25) (50)

SENSORY

KEY SENSORY POINTS

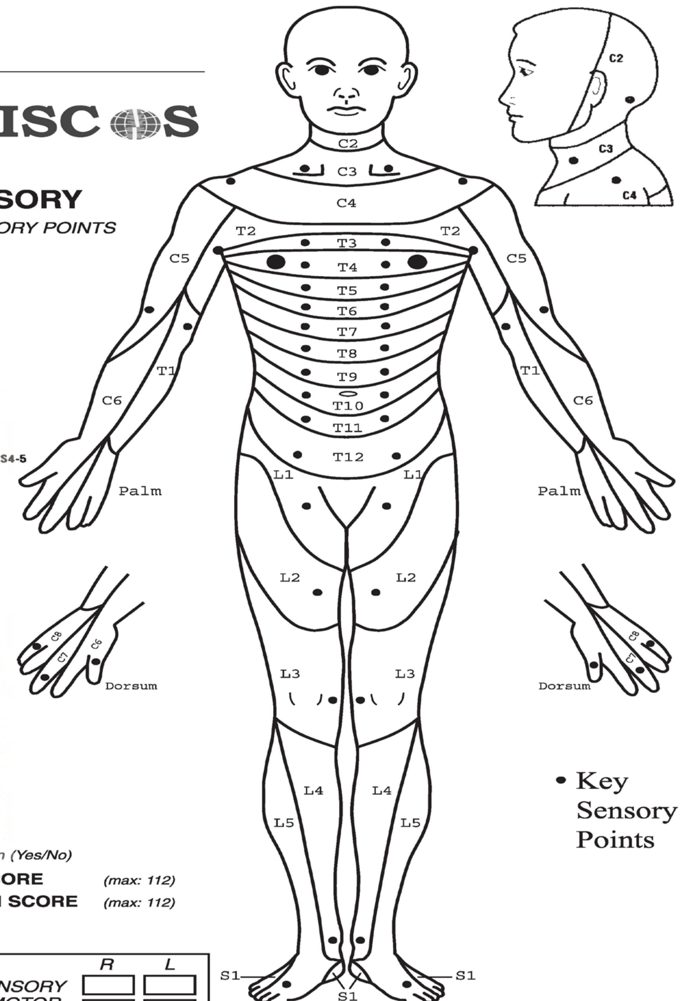
	LIGHT TOUCH R	LIGHT TOUCH L	PIN PRICK R	PIN PRICK L
C2				
C3				
C4				
C5				
C6				
C7				
C8				
T1				
T2				
T3				
T4				
T5				
T6				
T7				
T8				
T9				
T10				
T11				
T12				
L1				
L2				
L3				
L4				
L5				
S1				
S2				
S3				
S4-5				

0 = absent
1 = impaired
2 = normal
NT = not testable



☐ Any anal sensation (Yes/No)

TOTALS { ☐ + ☐ ☐ + ☐ = ☐ PIN PRICK SCORE (max: 112)
= ☐ LIGHT TOUCH SCORE (max: 112)
(MAXIMUM) (56) (56) (56) (56)



NEUROLOGICAL LEVEL		R	L	COMPLETE OR INCOMPLETE? ☐	ZONE OF PARTIAL PRESERVATION		R	L
The most caudal segment with normal function	SENSORY			Incomplete = Any sensory or motor function in S4-S5	Caudal extent of partially innervated segments	SENSORY		
	MOTOR			ASIA IMPAIRMENT SCALE ☐		MOTOR		

REV 03/06

Appendix 12 Spinal Cord Injury Secondary Conditions Scale (SCI-SCS)

Health Problem	Description	Rating
Pressure sore(s)	These develop as a skin rash or redness and progress to an infected sore. Also called skin ulcers, bedsores, and decubitus ulcers.	0 1 2 3
Injury caused by loss of sensation	Injury may occur because of a lack of sensation, such as burns from carrying hot liquids in the lap or sitting too close to a heater or fire.	0 1 2 3
Muscle spasms (spasticity)	Spasticity refers to uncontrolled, jerky muscle movements, such as uncontrolled muscle twitch or spasm. Often spasticity increases with infection or some kind of restriction, like a tight shoe or belt.	0 1 2 3
Contractures	A contracture is a limitation in range of motion caused by a shortening of the soft tissue around a joint, such as an elbow or hip. This occurs when a joint cannot move frequently enough through its range of motion. Pain often accompanies this problem.	0 1 2 3
Heterotopic bone ossification	This is an overgrowth of bone, often occurring after a fracture. Early signs include a loss of range of motion, local swelling and warmth at the area to the touch. This condition must be diagnosed by a physician.	0 1 2 3
Diabetes mellitus	Diabetes is a problem resulting from irregularities in blood sugar levels. Symptoms include frequent urination and excessive thirst. This condition is diagnosed by a physician.	0 1 2 3
Bladder dysfunction	Incontinence, bladder or kidney stones, kidney problems, urine leakage and urine back up are all symptoms of bladder dysfunction. NOTE: There is a separate item for urinary tract infections.	0 1 2 3
Bowel dysfunction	Diarrhea, constipation, "accidents," and associated problems are signs of bowel dysfunction.	0 1 2 3
Urinary tract infections	This includes infections such as cystitis and pseudomonas. Symptoms include pain when urinating, a burning sensation throughout the body, blood in the urine and cloudy urine.	0 1 2 3
Sexual dysfunction	This includes dissatisfaction with sexual functioning. Causes for dissatisfaction can be decreased sensation, changes in body image, difficulty in movement, and problems with bowel or bladder, like infections.	0 1 2 3
Autonomic dysreflexia	Autonomic dysreflexia, sometimes called hyperreflexia, results from interference in the body's temperature regulating systems. Symptoms of dysreflexia include sudden rises in blood pressure and sweating, skin blotches, goose bumps, pupil dilation and headache. It can also occur as the body's response to pain where an individual doesn't experience sensation.	0 1 2 3
Postural hypotension	This involves a strong sensation of lightheadedness following a change in position. It is caused by a sudden drop in blood pressure.	0 1 2 3
Circulatory problems	Circulatory problems involve the swelling of veins, feet or the occurrence of blood clots.	0 1 2 3
Respiratory problems	Symptoms of respiratory infections or problems include difficulty in breathing and increased secretions.	0 1 2 3
Chronic pain	This is usually experienced as chronic tingling, burning or dull aches. It may occur in an area that has little to no feeling.	0 1 2 3
Joint and muscle pain	This includes pain in specific muscle groups or joints. People who must overuse a particular muscle group, such as shoulder muscles, or who put too much strain on their joints are at risk of developing pain.	0 1 2 3

For the following 16 health problems, please rate how much each one affected your activities and independence in the last 3 months. If you have not experienced a secondary condition in the last 3 months or if it is an insignificant problem for you, please circle "0." Use the following scale to rate each of the secondary conditions.

0 = NOT experienced in the last 3 months or is an insignificant problem.
1 = MILD or INFREQUENT problem.
2 = MODERATE or OCCASIONAL problem.
3 = SIGNIFICANT or CHRONIC problem.

Appendix 13 List of excluded articles (Rapid review)

Record number	Title	Reference	Reason
1	Clinical Predictors of Recovery after Blunt Spinal Cord Trauma: Systematic Review	(Aarabi et al., 2012)	No information relating to predictors of early mortality.
2	Risk factors for mortality after spinal cord injury in the USA	(Cao et al., 2013)	No information relating to predictors of early mortality.
3	Gainful employment and risk of mortality after spinal cord injury: effects beyond that of demographic, injury and socio-economic factors	(Krause et al., 2012)	No information relating to predictors of early mortality.
4	Is age a key determinant of mortality and neurological outcome after acute traumatic spinal cord injury?	(Furlan, Bracken, et al., 2010)	No information relating to predictors of early mortality.
5	Long-term survival after severe trauma	(Mutschler et al., 2016)	No information relating to predictors of early mortality.
6	The effect of frailty on outcome after traumatic spinal cord injury	(Banaszek et al., 2019a)	Poster presentation
7	Sarcopenia, independent of age, predicts mortality and acute care adverse events in patients with traumatic spinal cord injury	(Banaszek et al., 2019b)	Poster presentation
8	Predictors of mortality in veterans with traumatic spinal cord injury	(Rabadi et al., 2013)	No information relating to predictors of early mortality
9	Causes of death following spinal cord injury during inpatient rehabilitation and the first five years after discharge. A Dutch cohort study	(Osterthun et al., 2014)	No information relating to predictors of early mortality.
10	Survival in Persons with Traumatic Spinal Cord Injury Receiving Structured Follow-Up in South India	(Barman et al., 2014)	No information relating to predictors of early mortality.

11	Clinical predictors of neurological outcome, functional status, and survival after traumatic spinal cord injury: a systematic review	(Wilson, Cadotte, et al., 2012)	Systematic review

Appendix 14 Data extraction form

Unique participant code:..............................
Site...

Variables according to International Basic Core Data Set and international acute guidelines	**Detail**
ISCoS - core data set	
Date of birth (YYYYMMDD)	
Sex (M/F) Length (in cm's) Weight (in kilograms)	
Date of injury (YYYYMMDD)	
Any intermediate hospitalizations prior to admittance to a level 1 trauma unit? Y/N Name of hospital (s): Date of admission and discharge: (number of days)	
Referral from other hospitals to GSH or ASCI Date of referral to GSH/ASCI Where was the patient kept in the referring hospital (Resuss, High care/ICU)? Ventilated or not? (Yes/No) Closed cervical reduction at referring hospital? (Yes/No) Surgical procedure at referral hospital? (Yes/No) Title of operation? Arrival with pressure ulcer? Yes/No	

1

Unique participant code:..............................
Site...

Treatment Time/date cervical reduction Reduction performed by: consultant/fellow/registrar/intern. ER Doctor Duration of cervical reduction from start to end-point Maximum weight used in cervical reduction Endpoint of cervical reduction-successful, failed (reason for failure- max weight used, pin slippage, doctor uncomfortable with further weight, patient neuro deterioration, other) Facet fracture present Y/N	
Admission to Acute SCI Unit (GSH)? Y/N	
Date of admission to acute care: Priority score **Weanability score** Age Radiological evidence lung pathology Pre-existing CCF, IHD or other cardiovascular disease Chronic alcoholic Severe TBI with GCS <9T or <13/15 Polytrauma Social Stability Permanent job or staying with family or a partner who is permanently employed, **financially stable Yes/No**	

2

Strong support system (family, friends) who makes a commitment to care for this patient following rehabilitation and who visits him regularly Yes/No Lives in a **Brick /RDP/Pre-fab house Yes/No** Stays in a shack or a Wendy house without easy access of an **ablution facility Yes/No** **Homeless/Lives on the street Yes/No** History of **chronic drug addiction** affecting patients' social stability/circumstances Yes/No Ventilation required: Date of onset ventilation Date of onset of weaning Date of off ventilator 24/24 Needs permanent home ventilator Yes/No Date of request for permanent home ventilator Date of arrival of permanent home ventilator	
Date of discharge from acute care to ASCI ward D15	
Date of referral to WCRC rehab: Date of response from WCRC Reason for non-acceptance from WCRC Date of transfer to WCRC	
Date of discharge from inpatient rehabilitation?	
Discharge destination?	…………………………………………

Unique participant code:.............................
Site..

Injury aetiology 1. Sport 2. Assault 3. Transport 4. Fall 5. Other traumatic cause 6. Non-traumatic SCI 9. Nonspecified	
Vertebral injury/dislocation 0 No 1 Yes	
Associated injury 0 No 1 Yes	
Co-morbidities 0 No 1Yes	If yes, specify...
Spinal surgery 0 No 1 Yes	
Ventilatory dependent at discharge 0 No 1 Yes, less than 24 hours per day at discharge 2 Yes, 24 hours per day at discharge 3 Yes, unknown number of hours per day at discharge 9 Unknown	

Neurological assessment according to international standards	**Admission**	**Discharge**
Date of assessment		
Sensory		
Sensory level **Right** C01-C08 T01-T12 L01-L05 S01-S05 Normal sensation		
Exact sensory level (ex C5)		
Sensory score admission (R)		
Sensory score discharge (R)		
Sensory level **Left** C01-C08 T01-T12 L01-L05 S01-S05 Normal sensation		

Exact sensory level (ex C5)		
Sensory score admission (L)		
Sensory score discharge (L)		
Total sensory score	/128	/128
Motor		
Motor level **Right** C01-C08 T01-T12 L01-L05 S01-S05 Normal sensation		
Exact motor level (ex C5)		
Motor score admission (R)		
Motor score discarge (R)		
Motor level **Left** C01-C08 T01-T12 L01-L05 S01-S05 Normal sensation		
Exact motor level (ex C5)		
Motor score on admission (L)		
Motor score at discharge (L)		
Total motor score		
Admission	/100	/100
ASIA Impairment Scale A Complete injury B Sensory incomplete injury C Motor incomplete injury D Motor incomplete injury E Normal.		
Secondary complications	On admission	Developed during stay
Pulmonary complications *Pneumonia* *Atelectasis*		
Pressure ulcer *Date of onset:* *Location (s):* *Size (Grade):* *Time (date) to heal:*		

Treatment method used: *Referral plastics Yes/No* *Place of Plastics procedure: Eerste River, GSH* *Date of plastics procedure*		
Urinary tract infection		
Spasticity		
Autonomic dysreflexia (AD)		
Deep vein thrombosis		
Lung embolism		
Orthostatic hypotension		
Cardiovascular disease		
Neuropathic pain		
Other secondary medical problems		
Processes of care 1yr follow up		
Access to specialist services 0 No 1Yes Who did you see?	....	
Access to community-based rehabilitation services 0 No 1 Yes		
Was inpatient rehab (WCRC) received? 0 No 1 Yes		
Did you receive any peer mentoring or joined a support group? 0 No 1 Yes		
Have you applied for a disability grant? 0 No 1 Yes Have you started receiving payment already? 0 No		

1 Yes	
Have you been readmitted to hospital since discharge from acute care? 0 No 1 Yes If yes, how many times?………………. Reason for hospitalisation (s):	
Outcomes at 1yr follow up	
Alive at 1yr 0 No 1 Yes If no, reason for death………………………	
Secondary complications	<u>*Since discharge to 1yr follow up*</u>
Pulmonary complications *Pneumonia* *Atelectasis*	
Pressure ulcer *Location (s):* *Size:* *Time to heal:* *Treatment method used:*	
Urinary tract infection	
Spasticity	
Autonomic dysreflexia (AD)	
Deep vein thrombosis	
Lung embolism	
Orthostatic hypotension	
Cardiovascular disease	
Neuropathic pain	
Other secondary medical problems	
<u>Return to work</u>	

Did you work prior to injury? 0 No 1 Yes If yes, what kind of work?....................				
Other self-reported and objective measures completed. 1. Spinal cord independence measure self-report 2. Quality of life (tree questions for SCI) and EQ-5D 3. Accelerometry (w/c user) 4. Self-efficacy scale (single item)	*Admission*	*Discharge*	*1yr f/u*	
Sociodemographic data				
Marital status (on admission and discharge) 1. Single 2. Married 3. Living together (cohabitation) 4. Separated 5. Other	Admission	Discharge		
Education level on admission 1. No formal education 2. Up to grade 7 3. Between grade 8 and 11 4. Matriculated 5. Some tertiary education 6. Tertiary diploma or degree 7.More than one tertiary degree				

Appendix 15 Editing services

PROSE & CONSONANTS

De Velde Estate, 5 De Beers Avenue,
Somerset West, 7130
+27(0)21 825 9815
chantelle@proseandconsonants.co
www.proseandconsonants.co

To whom it may concern

This letter serves to confirm that the thesis detailed below was edited by the undersigned editor. It was edited for language, grammar, spelling, punctuation, sentence construction, consistency and overall style and layout.

The editor endeavoured to ensure that the author's intended meaning was not altered during the editing process. All changes were tracked using the Microsoft Word track changes feature.

Author: Blake Boggenpoel
Title: The development of a health care decision- making model to improve survival of persons with traumatic spinal cord injuries (tSCI)

Sincerely,

Chantelle Hough Louw

ciep Chartered Institute of Editing and Proofreading

Professional EDITORS Guild

LegalWriting institute