EVIDENCE-BASED NURSING CARE FOR SPINAL IMMOBILISATION – A SYSTEMATIC REVIEW

by

MEGAN GELDENHUYS

A dissertation submitted in fulfilment of the requirements for the degree

MAGISTER CURATIONIS

in

NURSING: ETHOS AND PROFESSIONAL PRACTICE

in the

FACULTY OF HEALTH SCIENCES

at the

UNIVERSITY OF JOHANNESBURG

Supervisor: Prof Charlene Downing

Co-Supervisor: Prof Elzabé Nel

October 2019

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DEDICATION

To the registered nurses, enrolled nurses, enrolled nursing assistants and carers who tirelessly serve in emergency departments across South Africa, this is for you. And for your patients.

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Prof Charlene Downing, thank you for your professional guidance, your unending patience and your kindness. I am honoured and blessed to have had such a knowledgeable supervisor who cared so much, and who never stopped believing in me.

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Casper, you have sacrificed much, and you have given much. Thank you, a thousand times over, thank you.

Not to us, O Lord, not to us

but to your name be the glory,

because of your love

and faithfulness

(Psalm 115:1)

ABSTRACT

South Africa is a country burdened by a high incidence of trauma due to excessive rates of interpersonal violence and transport accidents. Spinal injury from trauma, although uncommon, usually has devastating consequences such as death or disability. A high degree of suspicion of spinal injury in all trauma patients is therefore encouraged, and spinal immobilisation is considered an accepted intervention to prevent progression of a potential injury. Traditional guidelines such as these lack reliable evidence to support the practice and have been founded on logical reasoning and expert opinion.

To establish evidence-based care, this systematic review seeks to answer the question 'What emergency nursing interventions used in blunt and penetrating trauma patients with suspected spinal injury produced the best patient outcomes?'

To answer this question, accepted methods of the systematic review process were adhered to. Six electronic databases were systematically searched to identify potentially relevant research. Sources selected based on pre-established criteria were critically appraised and analysed. Data extracted were narratively synthesised using an established framework to infer conclusions and make recommendations.

The search and selection yielded 19 sources relevant to the research question. Quality appraisal revealed that four out 19 studies were of a superior quality. The remaining evidence was moderate to weak.

Empirical research exploring interventions directed at suspected spinal injury was particularly diverse and difficult to synthesise. There was, however, consensus on some aspects. While evidence is insufficient to establish the efficacy and necessity of spinal immobilisation in blunt trauma, research does document adverse effects from the practice.

Equipping nurses to use the Canadian C-Spine (CCR) as a decision tool to remove and apply spinal immobilisation in stable trauma patients with suspected spinal injury

proved to be clinically effective and safe. A multi-centre implementation of this intervention demonstrated advantages for the patients as well as cost and time management benefits.

In penetrating trauma, spinal immobilisation was associated with an increased probability of secondary injury and increased mortality. In addition, no relationship was found between spinal immobilisation and the prevention of a complicating primary injury in this population group.

The conclusions of this review are inadequate to inform policy or change clinical practice based on limitations regarding the included studies and the research process. Although insufficient to replace current protocols, the guidance could be used to stimulate conversation and critical thinking among emergency nurses. In addition, the recommendations provide evidence to facilitate informed decision making in balancing the benefit of nursing interventions against the harms while considering the needs and values of the patient.

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CHAPTER ONE
ORIENTATION TO THE STUDY

1.1 INTRODUCTION

South Africa, a developing country, is burdened with a high rate of blunt and penetrating trauma, resulting in death and disabling injuries (Norman, Matzopoulos, Groenewald & Bradshaw, 2007:695). In 2013, 10% of the 458 933 deaths in South Africa were accidental, including causes such as assault, intentional harm and transport accidents (Statistics South Africa, 2013, para.1). The South African Road Accident Fund (RAF) announced the national festive season death toll for the period 1 December 2017 to 15 January 2018 at 1 676. According to the RAF, drunk driving, speed, unroadworthy cars and fatigue are factors that contribute towards a high rate of motor vehicle accidents in South Africa, resulting in death and injury (Jabavu, 2018:1). They moreover report that road accidents account for R33 billion in claims per annum.

A report by the World Health Organization (WHO) describes homicide as a leading cause of death in South Africa, with the homicide rate peaking in the 15-19 age group in males and the 30-44 age group in females (Norman et al., 2007:696). This ranks interpersonal violence higher than road traffic collisions as a cause for death and injuries in South Africa.

A demographic study done on trauma-related mortality in Pietermaritzburg, South Africa, tallied 10 644 patients who were treated for trauma in the city over two years. Of this total, 58.2% were due to interpersonal violence, namely assault, gunshot wounds and stabbings (Moodley, Aldous & Clarke, 2014:101). The incidence of trauma in South Africa, both violent as well as on the roads, is excessive when compared to global statistics. The WHO thus describes the premature mortality and disability that results from trauma as a burden to the country (Norman et al., 2007:695).

Spinal injury due to trauma is debilitating as it often results in a loss in quality of life, a decreased ability to work, and an increased dependence on family and society. Globally, traumatic spinal injury is frequently attributed to transport accidents and falls (Oteir, Smith, Stoelwinder, Middleton & Jennings, 2015:529). With such a high rate of trauma in South Africa, spinal injury is a major concern for emergency nurses across the country. Despite this, international research has established that spinal injury among trauma patients is a rare occurrence (Oteir et al., 2015:529), with an estimated incidence of 0.5% to 3% (Connor, Greaves, Porter & Bloch, 2013:146).

Although uncommon, in South Africa, the young, otherwise healthy and independent are the largest group to suffer from spinal injury. This is illustrated in a study that identified the epidemiological profile of patients admitted to an Acute Spinal Cord Injury Unit at Groote Schuur Hospital in Cape Town over 11 years. A total of 2 042 patients were identified with a mean age of 34 years and the dominant age group being 21-30 years. The same demographic study describes motor vehicle accidents, falls, gunshot wounds and stab wounds as the top four causes of spinal cord injury (Sothmann, Stander, Kruger & Dunn, 2015:836). While spinal cord injury from penetrating trauma is rare (Tatum, Melo, Dhillon, Smith, Yim, Barmparas & Ley, 2016:223), the Groote Schuur study is a reminder that the South African context is unique. Gunshot wounds and stab wounds are among the most common causes of spinal injury in South Africa, probably owing to the high rate of interpersonal violence in the country.

In keeping with the uniqueness of the South African setting, Moodley et al. (2014:104) conclude in their study of trauma in Pietermaritzburg that the referral system is poorly defined, and the capacity of emergency services is ill-equipped to handle the high volume of trauma in the city. As this is a likely example of the country's resources, it is imperative to ensure that the nursing management of patients at risk of spinal cord injury in South Africa's emergency departments is up to date and evidence-based.

1.2 BACKGROUND

1.2.1 Anatomical Structure

A basic understanding of the anatomy of the spinal cord and spinal column is required for appropriate nursing care for victims of trauma (Kanwaar, Delasobera, Hudson & Frohna, 2015:242). The spinal column is made up of 33 bony vertebrae that are held in place by strong ligaments. Seven cervical, 12 thoracic, five lumbar, five sacral and four fused coccygeal vertebrae are separated by intervertebral discs and create a hollow column that houses and protects the spinal cord (Kanwaar et al., 2015:242).

The lateral view of the spinal column is further divided into anterior, middle and posterior columns (Holwerda, 2017:The Three-Column Concept, para.2). The anterior column is bordered by the anterior longitudinal ligament and the anterior half of the vertebral body, disc and annulus. The middle column is bordered by the posterior longitudinal ligament and the posterior half of the vertebral body, disc and annulus. Lastly, the posterior column is defined by the facet joints, ligamentum flavum, the posterior elements and connecting ligaments (Connor et al., 2013:146).

Various types of spinal column fractures exist, and a complex classification system describes each fracture based on location and mechanism of injury (Kanwaar et al., 2015:242). Regardless of the classification, a spinal fracture is considered stable if only structures in the anterior column are involved. An unstable fracture spans across two or more lateral columns as structural stability is compromised (Holwerda, 2017:Stable and Unstable Fractures, para.4).

The spinal cord, contained within the spinal column, is a complex composition of nerve fibres and is responsible for conducting sensory and motor impulses from the brain to the rest of the body (Kanwaar et al., 2015:242). A spinal cord injury may or may not be associated with a spinal fracture. When an injury is present, it is considered complete if there is a total loss of motor and sensory function below the level of injury. If some sensory or motor function is retained, then the injury is deemed incomplete, and recovery is often more promising than a complete spinal cord injury (Kanwaar et al., 2015:265).

Interventions directed at preventing the progression of a spinal injury are based on an accepted theoretical model that conspicuous motion of the whole spine implies

fine movement of a potential spinal fracture. The theory extends to a concept that any movement of bony fragments of an unstable spinal fracture can potentially sever the spinal cord and risk secondary spinal cord injury (Hauswald, 2013:720). Immobilisation of the spine following trauma has, for decades, been thought to be crucial to prevent this secondary injury that could lead to neurological compromise. This practice, commonly used by emergency nurses, is based on the premise that restricting gross movement of the spine in the presence of suspected spinal injury will prevent devastating complications (Connor et al., 2013:146).

1.2.2 Traditional Management

The Advanced Trauma Life Support Program® (ATLS®), developed by the American College of Surgeons, is a programme that teaches an evidence-based system for the primary management of trauma patients in over 80 countries across the globe (Rotondo, 2018:Program Development, para. 2). ATLS® has been a global driving force behind the advocated practice of spinal immobilisation by means of external devices for the extrication, transport and stabilisation of all trauma patients (Abram & Bulstrode, 2010:218). In promoting safe practice, the programme encourages a high degree of suspicion of an unstable cervical spine for all trauma patients. Prompt commencement and maintenance of spinal immobilisation using external devices is recommended (American College of Surgeons, 2018:7-8), reiterating the idea that the intervention is the best protection against a secondary spinal injury.

Various external devices are used for the immobilisation of the injured patient, with each device intended to immobilise a different region of the spine (Holla, Huisman, Verdonschot, Goosen, Hosman & Hannink, 2016:2023). Although various orthotic devices exist, the most common and accepted means of stabilisation is the combination of a rigid neck collar, head blocks, and a long backboard to which the patient is strapped (Kornhall, Jørgensen, Brommeland, Hyldmo, Asbjørnsen, Dolven, Hansen & Jeppesen, 2017:1). This method of immobilisation is most often applied on the scene of the incident by pre-hospital personnel. Upon arrival in the emergency department, the rigid board and straps are usually removed, and the patient is placed on a stretcher mattress using a log-roll technique. International guidelines recommend that the rigid collar and head blocks be left in place and that the patient

be kept supine and immobile until a diagnosis is confirmed or excluded (Ham, Schoonhoven, Schuurmans & Leenen, 2016:1925).

1.2.3 The Benefit of Spinal Immobilisation

Ropper, Neal and Theodore (2015:266-267) explain the motivation behind limiting spinal movement following trauma as they report that between 3% and 25% of all spinal cord injuries occur during transport or in the course of management. Furthermore, they highlight that the cervical spine is particularly vulnerable as there is little support for the neck and less force is needed for dislocation than the thoracic and lumbar spine. The life-altering consequences of a cervical cord injury include quadriplegia and an inability to breathe independently. Noting that there is no high-level evidence to support spinal immobilisation following trauma, the authors rationalise the intervention as advantageous based on anatomical and biomechanical logic, as well as observational experience (Ropper et al., 2015:267).

The Norwegian Guidelines for the Pre-hospital Management of Adult Trauma Patients with Potential Spinal Injury support their recommendation of external spinal stabilisation with clinical experience and an anatomical standpoint (Kornhall et al., 2017:4). Additionally, a systematic review done in 2011 sought to establish best practice guidelines for the management of spinal cord injury spanning from pre-hospital care through to discharge and recovery. A recommendation for the acute management of spinal cord injury highlights the importance of immobilisation using a cervical collar and long backboard (Fehlings, Cadotte & Fehlings, 2011:1330).

Guidelines in favour of spinal immobilisation in the event of suspected spinal injury contend that the introduction of the practice in the 1970s corresponds with a decrease in mortality from spinal cord injury, and therefore advocate that it is valuable in preventing secondary spinal cord injury (Kornhall et al., 2017:4).

1.2.4 The Efficacy of Spinal Immobilisation

Various researchers have sought to establish evidence to support the practice of spinal immobilisation, particularly cervical spine immobilisation. To this end, a study was conducted at the University of Florida to determine the efficacy of cervical collars in reducing spinal motion. The degree of movement in surgically fractured cervical spines of cadavers was measured, with and without a rigid neck collar (Horodyski, DiPlaola, Conrad & Rechtine, 2011:513-519). The authors acknowledge that the benefits of using a rigid collar include creating awareness for both the patient and the caregiver that an injury may be present, and that caution is necessary. However, they conclude that, although collars provide some limitation in movement, they are insufficient for the immobilisation of an unstable cervical spine injury.

An alternate study compared the efficacy of four well-known cervical collars. The study found that, although there was variation between them, all four collars provided a significant reduction in neck movement. The collars are therefore described as efficient to provide immobilisation in the presence of suspected spinal injury (Karason, Reynisson, Sigvaldson & Sigurdsson, 2014:4).

A comparison between the restriction of movement provided by hard and soft neck collars found that rigid collars provide a limitation of flexion and extension of 59% and 47%, respectively, while providing 18% limitation of both left and right rotation. The same study found less limitation in movement provided by soft neck collars (Barati, Arazpour, Vameghi, Abdoli & Farmani, 2017:393).

A contradiction in published literature is demonstrated in the contrast of the studies described. This suggests that further research is necessary to bridge the gap regarding the efficacy of spinal immobilisation.

1.2.5 The Adverse Effects

In justification of the prescription of spinal immobilisation in suspected spinal injury, is the perception that the practice is benign. If this is indeed true, one may reason that the benefit outweighs the risk of an ineffective device (Abram & Bulstrode, 2010:218-219). On the contrary, recent research illustrates that the application of external immobilisers may be harmful.

Oteir et al. (2015:530) systematically reviewed literature to establish if suspected cervical spine injury should be immobilised or not. The enquiry observed that the application of a cervical collar increases mortality rates, conceals neck injuries, increases neurological deterioration, and increases intracranial pressure. The study by Karason et al. (2014:5) that found cervical collars to be efficient, also examined the safety of the orthotic. A significant increase in jugular venous pressure was reported in three out of the four collars they compared. An increase in intracranial pressure was attributed to the decreased venous flow that results from the pressure the collars exert on the jugular vein.

Despite the Norwegian guidelines advocating spinal immobilisation following trauma, the cervical collar is advised to be used with caution based on evidence documenting harm. An impediment in breathing and airway management, pain, agitation, non-compliance and mandibular nerve palsy are a few to name. The guideline further warns that the collar may worsen an injury by increasing the space between C1 and C2 vertebrae (Kornhall et al., 2017:6).

Adverse effects such as these suggest that a reconsideration in practice may be necessary. A recent South African recommendation comes with a heed to provide appropriate care to spinal injuries without causing harm. Moreover, it is advised that cervical collars and long backboards be avoided and replaced by safer methods of spinal motion restriction (Stanton, Hardcastle, Muhlbauer & van Zyl, 2017:8).

1.2.6 Problem Statement

Traditional guidelines regarding spinal immobilisation lack reliable evidence to support the practice. Recommendations have largely been founded on logical reasoning, expert opinion and tradition rather than best research evidence (Connor et al., 2013:147). The goal of nursing is to provide care that results in the best outcome for the patient. This is achieved through the delivery of care that is based on the best research evidence, integrated with patients' needs and clinical expertise (Gray, Grove & Sutherland, 2017:11).

In the wake of a plethora of new information regarding the management of suspected spinal injury in trauma, emergency nurses would benefit from a re-evaluation of guidelines. By routinely immobilising all trauma patients with a hard neck collar, head blocks and long backboard, emergency nurses risk providing care that is unnecessary and potentially harmful. This new information does not mean that the management of suspected spinal injury is unimportant (Stanton et al., 2017:5). Care of these patients remains a priority for healthcare professionals as the fear of complicating a suspected spinal injury and causing disability is in the forefront of the minds of many (Hauswald, 2013:720).

There is thus an urgent need for evidence-based guidance regarding appropriate nursing interventions for trauma patients who present in the emergency department with suspected spinal injury. To address the issue at hand, this systematic review seeks to answer the question 'What emergency nursing interventions used in blunt and penetrating trauma patients with suspected spinal injury produced the best patient outcomes?'

1.3 RESEARCH PURPOSE

The purpose of this study was to systematically review primary research studies related to the acute management of suspected spinal injury in adult patients following blunt and penetrating trauma, and to make recommendations regarding evidence-based nursing care of trauma patients in the emergency department.

1.4 RESEARCH OBJECTIVES

- To critically identify, examine and evaluate primary studies of a quantitative nature to determine the best research evidence regarding nursing interventions for adult trauma patients with suspected spinal injury.
- To formulate evidence-based recommendations regarding nursing interventions of adult trauma patients with suspected spinal injury in the emergency department.

1.5 DEFINITION OF KEYS TERMS

1.5.1 Spinal Immobilisation

Spinal immobilisation involves the placement of external devices designed to limit movement. This is founded on the principle that immobilisation will prevent gross movement and therefore prevent secondary injury of the spine (Connor et al., 2013:146). For this systematic review, spinal immobilisation refers to the use of external devices, such as hard neck collars or head blocks, on a patient who has sustained a traumatic mechanism of injury, to reduce spinal motion.

1.5.2 Systematic Review

A systematic review is a structured summary of primary research, conducted according to a specific and reproducible methodology (Davis, 2016:60). This systematic review aimed to systematically identify, appraise and synthesise results from all primary research studies related to interventions directed at suspected spinal injury.

1.5.3 Evidence-Based Practice

Evidence-based practice is an intentional and deliberate assimilation of evidence from research into clinical practice. This integration of knowledge and practice forms a foundation for nursing interventions that are safe, effective and produce improved patient outcomes (Matos, 2017:11). For this systematic review, the evidence from previous studies was used to generate guidelines for the nursing management of suspected spinal injury following trauma.

1.6 RESEARCH DESIGN AND METHOD

1.6.1 Research Design

Quantitative research seeks to understand the nature of relationships between two or more variables. This design is objective in nature and employs traditional methods of enquiry that are highly structured and formal. Quantitative research uses

numerical data to understand the phenomenon while focusing on the effectiveness, appropriateness and feasibility of an intervention (Gray et al., 2017:3). This systematic review sought evidence regarding effective and safe nursing interventions for trauma patients with suspected spinal injury to produce the best possible patient outcome. A quantitative design was therefore appropriate for this study.

1.6.2 Research Method

A systematic review is a research design that synthesises existing research to present a thorough, unbiased summary of evidence on a specific topic (Davis, 2016:61). A fundamental characteristic of the design is the minimisation of bias through a standardised and systematic process that aims to provide valid and reliable results (Askie & Offringa, 2015:405). The methodology for this systematic review is based on internationally accepted processes outlined in the Joanna Briggs Reviewer's Manual (Peters, Godfrey, McInerney, Soares, Khalil & Parker, 2017:11.3). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used as a framework for describing the steps followed (Moher Liberati, Tetzlaff & Altman, 2009:266).

1.6.3 Protocol

A research proposal detailing a protocol for the systematic review was written prior to the study's commencement. The proposal was submitted to and approved by the Higher Degrees Committee and Research Ethics Committee at the University of Johannesburg's Faculty of Health Sciences (Addendum A and B) in November 2017.

1.6.4 Eligibility Criteria

The eligibility criteria determine the grounds for inclusion of relevant studies in the review. The eligibility criteria were developed *a priori* and were constructed based on the concepts of the research question (Peters et al., 2017:11.3.6). Tabulated inclusion and exclusion criteria (Addendum C) detail the types of participants, core concepts, contexts and types of studies that were included.

1.6.5 Information Sources

Six academic databases were searched as sources for information and are detailed in Chapter Four. Reference lists of potentially relevant publications were scanned to further identify studies for inclusion.

1.6.6 Search Strategy

A search strategy was constructed using key words from the research question. Synonyms from each keyword were mapped and words were strung together using Boolean phrases and truncation where appropriate. The search aimed to capture a comprehensive list of primary studies and is detailed in Chapter Four (Peters et al., 2017:11.2.5). The full search strategy is attached as Addendum D.

1.6.7 Study Selection

The results list from each database search was screened in a stepwise, systematic manner. Initially, each title was screened for relevancy based on the eligibility criteria. Following the exclusion of irrelevant titles, the abstracts, and subsequently the full texts of each potentially relevant study, were screened (Peters et al., 2017:11.3.7.2).

The organisation of results lists and citations assisted with this process (Holly, Salmond & Saimbert, 2012:23). Mendeley Software was used for citation management and an Access database was created to manage results lists at various stages of screening. An example of citation management on the Access database is attached as Addendum E. Reasons for excluding records that did not meet eligibility criteria in the final screen is attached as Addendum F.

The process of screening was conducted independently by the primary reviewer, with input from an external reviewer, and is detailed in Chapter Four.

1.6.8 Quality Appraisal

Each relevant included study was quality appraised using appropriate checklists from the Critical Appraisal Skills Program (CASP) (*Critical Appraisal Skills Programme*, 2018:CASP Checklists). An example of a completed CASP checklist for each included design is attached as Addendum G, H and I.

1.6.9 Data Extraction

Relevant data were extracted from included articles using two standardised data extraction forms. The first data extraction form aimed to capture narrative data such as demographics, aims, methodology population, intervention and conclusions. The second data extraction form aimed to capture statistical results from each study, including the outcome, descriptive statistic and direction of effect (Peters et al., 2017:11.2.7).

Data extraction is detailed in Chapter Four, and an example of the narrative and statistical data extraction form is attached as Addendum J and K, respectively.

1.6.10 Data Synthesis

A meta-analysis is a statistical synthesis of results that compliments a systematic review by increasing the size of the population, thereby increasing the statistical power of results (Rodseth & Marais, 2016:32). A meta-analysis was inappropriate for this review as included articles were methodologically and clinically heterogenous. Statistical synthesis was therefore impossible.

Extracted data were narratively synthesised using a systematic methodology. A framework for narrative synthesis by the Economic and Social Research Council (ESCR) Methods Program was followed (Popay, Roberts, Sowden, Petticrew, Arai, Rodgers, Britten, Roen & Duffy, 2006:11-23). The narrative synthesis is detailed in Chapter Five.

1.7 ETHICAL CONSIDERATIONS

Systematic reviews are placed at the top of the pyramid of the evidence hierarchy and are considered one of the most reliable sources of evidence to support clinical practice (Grove, Burns & Gray, 2013:30). The nature of a systematic review is such that it aims to provide a thorough and impartial presentation of previous studies conducted on a topic (Wormald & Evans, 2018:27). This attempt at publishing comprehensive results is one reason why systematic reviews are esteemed in the world of research. The method is also often highly regarded because it is systematic and reproducible. Wormald and Evans (2018:27) highlight that there are fewer obstacles, such as ethics committee approval, to publishing a systematic review. This, coupled with a respected reputation, has made the method a popular one and has resulted in an increase in published systematic reviews in recent years. Nevertheless, these distinguishing features of strength may place the systematic review in a precarious position in which it is susceptible to ethical weaknesses (Vergnes, Marchal-Sixou, Nabet, Maret & Hamel, 2010:771). This section will discuss a few areas of vulnerability regarding ethics in systematic reviews, as well as measures implemented in this study to guard against these.

1.7.1 Redundancy

The Merriam-Webster Dictionary defines the word 'redundancy' as superfluous repetition (Merriam-Webster, 2018: redundancy. para.1). The recent increase in published systematic reviews poses a risk of redundancy whereby resources are used to conduct and publish literature that is an unnecessary duplication of that which has already been published (Wormald & Evans, 2018:27). In these instances, resources wasted include time and money, as well as space in a journal that could be used for work that is not redundant.

In preparation for this systematic review, a preliminary online search was directed at identifying other systematic reviews related to nursing interventions for suspected spinal injury within the South African context. While numerous reviews related to the pre-hospital management of suspected spinal injury were found, none were specific to the nursing discipline. Furthermore, not all of the reviews identified were

systematic, and only one pre-hospital review was conducted by South African authors (Stanton et al., 2017:4-8).

Another aspect related to redundancy involves including multiple publications of the same primary study in a systematic review. Wagner and Wiffen (2011:131) describe how this will most likely alter the results of the review, and they liken the practice to 'double counting' patients in a study. Although the root of this dilemma lies in publishing duplicated primary studies, the author of a systematic review should be cognisant of the risk.

A critical step in the systematic review process is the removal of duplicates from the list of retrieved articles following a systematic search (Ahn & Kang, 2018:105). Mendeley Software was used for citation management in this review. The 'remove duplicates' tool on the program was utilised following the upload of results lists from each database search as a primary step in avoiding duplication.

Following the systematic search, three relevant published papers by the same author were retrieved from three different journals. Scrutiny of the details regarding methods and results revealed all three articles were based on the same study. To avoid the 'double counting' described by Wagner and Wiffen (2011:131), two of these papers were excluded and only the article specific to nursing care in the emergency department (Ham et al., 2016:1024-1931) was included in the review.

The systematic search also identified multiple relevant systematic reviews with primary studies overlapping across various reviews as well as in the sample for this review. To avoid redundancy and skewed results, the overlapping studies were removed from the sample. Two systematic reviews and one cohort study were excluded in the final screen for this reason.

1.7.2 Reviewer Bias

The outcome of a systematic review is often trusted as a source of best research evidence and is therefore frequently used as the foundation for clinical standards (Vergnes et al., 2010:772). In the interest of the patients, authors of systematic

reviews carry a weighty responsibility in generating accurate results (Wormald & Evans, 2018:28). One of the greatest threats to accuracy is bias. Biased results are those that have been skewed in a particular direction by the author of the review, either intentionally or unintentionally (Wager & Wiffen, 2011:133). Despite the explicit methodology involved in a systematic review, there remains a component of partiality in the selection of studies for inclusion (Vergnes et al., 2010:772).

Wormald and Evans (2018:28) suggest an *a priori* plan for accurate data collection, extraction and synthesis as an important step in avoiding bias. In preparation for this review, a research proposal was compiled to establish a framework for the implementation of a structured process. The proposal was submitted to and approved by the Faculty of Health Sciences at the University of Johannesburg (Addendum A).

It is generally accepted that at least two reviewers be involved in the process of selecting articles for a systematic review as well as data extraction and synthesis (Wager & Wiffen, 2011:133). In so doing, there is less subjectivity in the process and therefore less risk of introducing bias. While generating evidence was an important objective of this review, the primary motivation was the pursuit of a Master's degree in nursing science from the University of Johannesburg. To ensure that the work evaluated was individual, the review process was conducted independently, under stewardship of a supervisor from the university. To counter the risk of bias in these circumstances, the expert opinion of an external reviewer was employed during the screening phase.

As a further method of eliminating reviewer bias, the Cochrane Collaboration recommends a thorough search of a range of sources to identify as many studies done on the topic as possible (Higgins, Thomas, Chandler, Cumpston, Li, Page & Welch, 2019:4.2.2, para 2). Accordingly, six databases were searched, including CINAHL to ensure relevancy to the field of nursing, and Sabinet to remain valid to the South African context.

1.7.3 Plagiarism

Plagiarism can be defined as using the original words or ideas of another author without due acknowledgement and thereby creating the pretence that they are one's own. Authors of systematic reviews should be particularly attentive of this ethical misconduct as a review is almost entirely composed of the work of others (Wager & Wiffen, 2011:132).

Plagiarism was avoided by paraphrasing the words and ideas from texts as far as possible. Furthermore, due acknowledgement is given to authors using the Harvard referencing system.

1.7.4 Transparency

Systematic reviews, and therefore clinical guidelines, are liable to be swayed by authors or funders who may profit from biomedical results (Wormald & Evans, 2018:29). The motivation behind being partial towards the outcome of a systematic review may be financial, personal, political or academic. Conflicting or competing interests such as these are not inherently wrong, but they do jeopardise the transparency of the review if they have an influence on the published results and, consequently, the clinical guidelines that are then developed based on the review (Wager & Wiffen, 2011:133).

It is therefore imperative that any conflicting interests be declared in the final publication, as well as the source of funding for the review (Vergnes et al., 2010:772). Wager and Wiffen (2011:133) advise that it is good clinical practice for the author to declare such interests, even if he or she is confident that the results are unbiased.

No funding was received for this review. The primary researcher, supervisor, co-supervisor, statistician and external reviewer declare no competing interests.

1.7.5 Integrity

Considerable attention is given to the ethical approval of primary studies. This is a direct result of historical biomedical research that grossly disregarded the dignity,

wellbeing and safety of human beings (Vergnes et al., 2010:771). It is considered a serious ethical dilemma to base clinical practice guidelines on the results of a study that has not met fundamental ethical criteria (Jokstad, 2017:181). Consequently, ethical review boards exist for the protection of human participants in biomedical research (Vergnes et al., 2010:771).

Despite a recent surge in systematic reviews to synthesise primary research, Vergnes et al. (2010:771) point out that very little attention is given to the ethical aspects of a systematic review, and speculate that this is most likely due to the secondary nature of the research method. The deficit in this area of ethical accountability in systematic reviews begs the question as to whether it is possible to include primary studies that are unethical (Jokstad, 2017:179).

There exists, among the academic community, an erroneous assumption that the primary studies used in a systematic review have been conducted in a manner that respects essential ethical criteria. Yet, the methodology of a systematic review does not provide any screening against the inclusion of studies that are ethically questionable. In reality, the ideal to include exhaustive literature may encourage the inclusion of irregular research (Vergnes et al., 2010:771). Due to global regulations regarding the ethical conduct of the conditions under which research is conducted, the risk of including unethical primary studies is a small one, but it is a risk nonetheless (Vergnes et al., 2010:771). The inclusion of such primary studies may warp the integrity of the results of a systematic review.

A proposed strategy to address the ethical assessment for this systematic review was based on the articles by Vergnes et al. (2010) and Jokstad (2017). Paramount in the approach is that the author of the systematic review be mindful of the ethical criteria of primary studies throughout the research process. Consequently, documented ethical approval of primary studies was actively sought throughout the review process and recorded on the data extraction form.

Where no documented ethical approval was identified, the first author of the study was contacted via email requesting conformation of either ethical approval, or a waiver thereof. All the emails remain unanswered. Under these circumstances, an

assessment of the study based on the principles of the Declaration of Helsinki was conducted to confirm that included studies met the basic principles of ethical research. Informed consent, the protection of humans, the qualification of the researcher and a risk versus benefit assessment comprised the foundation of the assessment.

To enhance transparency, ethical considerations of included studies has been tabulated and is attached as Addendum L.

Ethical approval for this systematic review was granted by the Research Ethics Committee (REC) of the Faculty of Health Sciences at the University of Johannesburg (Addendum B).

1.8 RELIABILITY AND VALIDITY

A priority in research is to generate information that reflects the truth (Polit & Beck, 2014:72). The pursuit of truth in this systematic review aims to reveal interventions effective at protecting a suspected spinal injury resulting from trauma that are as safe and comfortable as reasonably possible and can be implemented by nurses in the emergency department. The degree to which the results of a research study correspond to the truth is directly influenced by the methods used in the pursuit of answers. The terms 'validity' and 'reliability' describe the quality of these methods and are therefore also used as a yardstick to determine the trueness of the research (Polit & Beck, 2014:71-72).

1.8.1 Reliability

Reliability is concerned with the consistency with which information is obtained to produce results that are accurate and dependable (Polit & Beck, 2014:72). The principle of reliability in research is directly related to the consistency of the measurement of the phenomenon of interest. If there is consistency in the measurement methods, then the results are more likely to be true, and less likely to be random (Grove et al., 2013:389). Reliability in a systematic review is therefore

largely related to the methods used to obtain a sample of relevant articles (Ali & Usman, 2018:133).

A reliable search is the identification of studies based on pre-determined eligibility criteria, rather than on the personal judgement of the reviewer (McCrae, Blackstock & Purssell, 2015:1274). Reliability is further concerned with transparent reporting and a consistent search strategy to enable a second reviewer to repeat the search and obtain the same results (Ali & Usman, 2018:135).

The inclusion and exclusion criteria for this systematic review were determined *a priori,* and were based on constructs from the research question. The PRISMA guidelines (Moher et al., 2009:266) were used as a framework for reporting the review. Transparent reporting is intended to facilitate objective judgement regarding the rigour of methods and to capacitate replicability.

1.8.2 Validity

Validity refers to the robustness of the study to execute a methodology that is, as far as reasonably possible, free from error and fallacy. Broadly described, it is the dependability of the research (Polit & Beck, 2014:72), and is classified into internal and external validity. Internal validity refers to the outcome being a true consequence of the intervention observed rather than that of extraneous variables. External validity is the degree to which the results can be generalised to a population greater than the sample (Grove et al., 2013:199-202).

Internal validity is established in a systematic review by executing a rigorous methodology. A strategy for promoting internal validity is conformance with standardised methods of the systematic process (Biondi-Zocca, Lortrionte, Landoni & Modena, 2011:167). Furthermore, intentional interventions to protect the design against the risk of bias contributed to ensuring results are a reflection of the truth (Holly et al., 2012:14).

Equally important is the internal validity of included studies. As Wright and colleagues explain (2007:27), the inclusion of poor-quality studies will result in weak

evidence generated by the review, thereby compromising the dependability of the conclusions. Identifying the steps in the research process, determining study strengths and weaknesses, and evaluating the credibility of included studies further contribute to the validity of the review (Grove et al., 2013:454-462).

Internal validity was addressed in this review by the quality appraisal of each individual included study using the CASP checklist (Boland, Cherry & Dickson, 2014:71). Regardless of quality, all studies that met inclusion criteria were included. However, the results of the quality appraisal process are tabulated to enable readers to make objective judgements regarding the strength and generalisability of the evidence.

External validity in systematic reviews is described as difficult to address. While the assessment of internal validity is generally straightforward, external validity is described as an open-ended judgement that is largely left to the consumer of the research (Biondi-Zoccai et al., 2011:165).

Being mindful of external validity, the population and context of interest are defined and described in subsequent chapters to allow readers to make sound judgements regarding external validity.

1.9 CHAPTER LAYOUT

Chapter One – Orientation to the study

A brief background on the topic of interest and rationale for undertaking the review is presented. The chapter further outlines the aims, objectives and methodology of the study. A discussion on ethical principles and reliability and validity conclude the chapter.

Chapter Two – Conceptual definitions and literature review

Conceptual definitions of constructs in the research question aims to establish the boundaries of the study. A literature review serves to operationally clarify concepts as well as illustrate what is known on the topic.

Chapter Three – Methodology and pilot study

This chapter describes the standardised process in the systematic review methodology, as well as components that were tested for feasibility in the pilot study.

Chapter Four – Description of the research process and included studies

A description of the application of the standardised systematic review process serves to detail precisely what the researcher did to reach results. In addition, the chapter introduces and briefly describes primary sources included in the review.

Chapter Five – Results

This chapter describes the narrative synthesis of included studies that make up the results of the review.

Chapter Six – Discussion, limitations and recommendations

Results from the systematic review are discussed within the context of other evidence. Limitations of included studies and of the review process are explicated and recommendations regarding nursing interventions for suspected spinal injury are presented.

1.10 OUTCOMES

This review sought to identify, clarify and define reported interventions rendered to trauma patients with the goal of preventing the progression of a suspected spinal injury. The documented patient outcomes from these interventions were sought from quantitative research. These outcomes were explored, compared and synthesised into a comprehensive conclusion.

The synthesised conclusions from interventions and outcomes were drawn on to establish recommendations regarding the emergency nursing care of suspected spinal injury.

1.11 SUMMARY

South Africa is a country burdened by a high incidence of trauma (Norman et al., 2007:649) due to excessive rates of interpersonal violence and transport accidents (Moodley et al., 2014:101; Jabavu, 2018:1). Spinal injury from trauma, although uncommon, usually has devastating consequences such as death or disability (Oteir et al., 2015:529).

Healthcare professionals are often cognisant of the life-altering implications of spinal injury when providing acute care to victims of trauma (Hauswald, 2013:720). A high degree of suspicion of spinal injury in all trauma patients is therefore encouraged, and spinal immobilisation is considered an accepted intervention to prevent the progression of a potential injury (The American College of Surgeons, 2018:8). Traditional guidelines such as these lack reliable evidence to support the practice and have been founded on logical reasoning and expert opinion (Connor et al., 2013:147).

To establish evidence-based care, this systematic review sought to answer the question 'What emergency nursing interventions used in blunt and penetrating trauma patients with suspected spinal injury produced the best patient outcomes?'

The purpose of this study was to systematically review primary research studies related to the acute management of suspected spinal injury following blunt and penetrating trauma, and to make recommendations regarding evidence-based nursing care of trauma patients in the emergency department.

To achieve this goal, standardised methods of systematic review, synthesis and reporting have been adhered to. Every effort has been made to ensure ethical principles were respected and a rigorous process aimed to produce valid and reliable results. In Chapter Two, the conceptual definitions and literature review is presented.

CHAPTER TWO
CONCEPTUAL DEFINITIONS AND LITERATURE REVIEW

2.1 INTRODUCTION

A systematic review attempts to integrate all primary research relevant to an explicit research question into a comprehensive evidence-based conclusion (Higgins & Green, 2011:1.2.2) and is therefore a valuable tool for practice nurses, educators and policymakers to provide high-quality patient care (Davis, 2016:62).

As with primary research, the review question directs the investigation (Hopp & Rittenmeyer, 2015:1366). Constructs from a clear research question are used first to establish eligibility criteria (McCrae, Blackstock & Purssell, 2015:1270), and second to build a search strategy (Rodseth & Marais, 2016:33). In this way, the aims and objectives determine the framework of the study and demarcate the boundaries of the literature search (McCrae et al., 2015:1270). Deviation from these standards risks introducing bias as it suggests that studies were chosen for convenience rather than based on strict search and eligibility criteria that were driven by the question (McCrae et al., 2015:1274).

To this end, this chapter is dedicated to the delineation and explanation of concepts in the research question. The definition of terms aims to provide conceptual explanations of constructs, while a literature review serves to operationally clarify concepts and illustrate what is known on the topic. This explanation of conceptual and operational meanings of concepts in the research question intends to clarify and

justify the eligibility criteria and establish clear boundaries for search and study selection.

2.2 CONCEPTUAL DEFINITIONS

Constructs from the question “What emergency nursing interventions used in blunt and penetrating trauma patients with suspected spinal injury produced the best patient outcome?” were used to construct the eligibility criteria and search strategy (Hopp & Rittenmeyer, 2015:1366).

The elements ‘emergency nursing interventions’, ‘suspected spinal injury’, ‘blunt and penetrating trauma’ and ‘best patient outcome’ were deconstructed to generate a skeleton for the search. From these concepts, the terms ‘nurse’, ‘nursing’, ‘emergency nursing’, ‘nursing intervention’, ‘blunt and penetrating trauma’, ‘suspected spinal injury’ and ‘patient outcome’ were extracted.

Conceptual definitions of components from the question clarify meaning, highlight the aims and objectives, and establish a framework for the study. The term 'evidence-based care' has also been defined as it is a concept fundamental to the aims and objectives of the review.

2.2.1 The Nurse

The International Council of Nurses (ICN) describes a nurse as a professional who has completed a formal programme of education integrating elements of behavioural, life and nursing sciences, and is authorised by a regulatory body to care for individuals, families and communities. Caring is executed within the scope of practice determined by both the level of education completed by the nurse as well as the boundaries laid out by the authorising body. Nursing education prepares the nurse for his or her role within the areas of general nursing care, leadership, speciality nursing or advanced practice (International Council of Nurses, 2019:Definition of a Nurse, para.4).

2.2.1.1 Authorisation

The South African Nursing Council (SANC), as an autonomous and financially independent organisation, holds the mandate to establish and maintain nursing education and standards of care in the Republic of South Africa (South African Nursing Council, 2019:What is the South African Nursing Council?, para.1). As the custodian of nursing, the organisation fulfils its role by determining conditions to be complied with that entitle a nurse to practice in the clinical setting. These conditions are detailed in the Nursing Act (No. 33 of 2005), and are freely available on the SANC website (South African Nursing Council, 2006:25-31).

As stipulated in the Nursing Act, registration with the council is dependent on the qualification held and is a prerequisite to practice (South African Nursing Council, 2019:Setting and Monitoring of Standards, para.4).

2.2.1.2 Education

Nursing education in South Africa is directed at the personal and professional advancement of the adult nursing student and encourages cognitive and psychomotor development through the achievement of prescribed outcomes. The critical and creative thinking skills fostered are intended to equip the nurse with problem-solving skills. Such analytical thinking is necessary for the gathering and interpretation of data, the drawing of conclusions, and implementation of appropriate interventions that will produce the best outcome for the patient (South African Nursing Council, 1995:3).

Regulated by the SANC, nursing qualifications are offered by various private and public educational institutions throughout the country. A certificate, diploma, bachelor's degree and an advanced post-basic diploma equip nurses to practice within the scope dictated by the level of qualification obtained. The scope is set out in the laws of the country, established in parliament and enforced by the SANC (Mahlathi & Dlamini, 2017:10).

2.2.1.3 The Nurse as a Whole Person

Qualified and authorised, the nurse functions as a sensitive and therapeutic professional person. The Theory of Health Promotion by the University of Johannesburg's Department of Nursing, defines a 'person' as one who encompasses the dimensions body, mind and spirit, and functions in an integrated and interactive manner with the environment. The environment is further categorised as internal and external, with the elements of the person constituting the internal environment and the physical, social and spiritual dimensions reflecting the external environment (University of Johannesburg, 2010:5).

As the nurse is a whole and independent person, he or she functions by mobilising these resources in the internal and external environment. Cognitive knowledge, skill and physical capacity are integrated with personal morals, values and ethics to provide care using tools available in the physical environment as a collaborating member of a multi-professional healthcare team with the needs and expectations of the patient at the centre (University of Johannesburg, 2010:5).

2.2.2 Nursing

The Nursing Act (No.33 of 2005) provides a definition of 'nursing' in South Africa. Here, the profession is described as caring for and treating a healthcare user to achieve and maintain health, or comfort and dignity until death. The SANC explicitly states that nursing is performed by a person who is registered in terms of Section 31 of the Act (South African Nursing Council, 2006:6).

The SANC, responsible for maintaining a standard of care, regulates nursing in South Africa by means of a regulation that details the scope within which a registered nurse may practice. This regulation further elaborates on the definition of nursing by outlining the responsibilities of each category of nurse. The responsibilities of a registered nurse are listed within the context of the nursing regimen. The nursing regimen is, in turn, defined as interventions executed by the nurse to impact preventative, promotive, curative or rehabilitative aspects of health care through the implementation of systematic care plans (South African Nursing Council & Minister of Health and Welfare, 1991:np).

The definition of the term ‘nursing’ by the SANC is congruent with the meaning described by the University of Johannesburg’s Theory of Health Promotion. Labelled as an interactive process to facilitate the promotion of health through the mobilisation of resources, emphasis is placed on the idea that nursing is methodical and conscientious. Synthesising knowledge and skill gained in training, the nurse uses critical thinking to cultivate holistic wellbeing through an intentional process of assessment, planning, implementation and evaluation (University of Johannesburg, 2010:5-6).

A review of literature revealed multiple definitions of ‘nursing’. However variant they may be, there are common elements in the clarification of the act of nursing. A scientific process intended to promote physical or psychosocial health, prevent illness and care for the ill, injured and dying forms the core of the professional conduct. Moreover, the beneficiary of the care may be an individual, family, or community of any age and at any stage of the dynamic health status (International Council of Nurses, 2019. Definition of a Nurse, para.4).

2.2.3 Emergency Nursing

The definition of ‘nursing’ broadly encompasses the many specialities that focus on specific settings or types of patients (International Council of Nurses, 2019:Definition of a Nurse, para.4). Emergency nursing is a speciality that implements the practice of nursing, with all its associated roles and responsibilities, for the patient who is in the emergent or acute phase of illness or injury. Also described as acute care, emergency nursing is dynamic in nature. It is characterised by the short-term stabilisation of injuries, new onset of illness, or the acute exacerbation of a chronic illness (Wolf*,* Brysiewicz, Lobue, Heyns, Bell, Coetzee et al*.,* 2012:175).

The general definition of nursing includes all aspects of preventative, promotive, curative or rehabilitative health promotion (South African Nursing Council & Minister of Health and Welfare, 1991:np). Emergency nursing, however, is especially focused on the early or critical stage of a physical or psychosocial presentation and is thus focused on promotive and curative elements rather than preventative or rehabilitative treatment (Wolf et al., 2012:175).

The patient profile of an emergency department is diverse in age, epidemiology as well as severity of illness or injury. Emergency nursing interventions may therefore range from minor care to advanced life support (Curtis & Ramsden, 2011:4). Within this environment, nurses care for patients through the integration of assessment and identification of life and limb-threatening problems by delivering prioritised interventions while providing information and support to patients and their families (Wolf et al., 2012:175).

2.2.4 Nursing Intervention

A nursing intervention can be described as an activity or set of activities, executed to change the likely course of events in the dynamic process of health (Bulechek, Butcher, Dochterman & Wagner, 2018:2). Chosen following an assessment, activities are evidence-based and integrated with knowledge and skill to produce a positive patient outcome (Reising, 2016:667).

While the act of nursing is delivered via the nursing process, it is the intervention that forms the fundamental building blocks of the care being delivered. Tasks are fulfilled to meet individualised patient goals. The outcome of the intervention is evaluated for effectiveness of care and then forms a basis for continuous assessment (Reising, 2016:667).

Although the term ‘nursing intervention’ is commonplace in academic literature, Reising (2016:667) observes that conceptualisation of the idea is often vague. Elaborating on this confusion, an inconsistency regarding what constitutes an intervention in familiar nursing models is highlighted. While some define only the action done to a patient as an intervention, others include any task directed towards improving patient outcome in the definition.

This systematic review aims to provide evidence for emergency nurses to make informed decisions regarding interventions for a trauma patient with a suspected

spinal injury. With this in mind, the term ‘nursing interventions’ will refer to the intentional, scientific and methodical interception on the health status of the patient.

2.2.5 Trauma

Trauma can be described as damage to any part of the human body, such as skin, muscle or bone, caused by an external force or object (Merrium-Webster, 2019:Trauma, para.1). The extrinsic agent that causes tissue injury does so via impact and the transfer of energy. The resulting ‘trauma’ is a colloquial term commonly used among healthcare providers to group injury-related presentations as well as the population of patients who have sustained such injury. Although generally used and accepted to describe conditions, patient groups as well as physical injury, the literary meaning of the word ‘trauma’ is the last of these (Eaton, 2005:15).

Establishing the causality of the trauma is an important step in the nursing process as different forces are likely to cause different patterns of injuries. Altered mentation, intoxication, fear, severe pain and massive distracting injuries are among some factors that may challenge accurate history taking and physical assessment. In such instances, an awareness of the mechanism that caused the injury can be helpful in providing insight into the nature and anatomical location of injuries (Eaton, 2005:15).

2.2.5.1 Blunt and Penetrating Trauma

When defining the mechanism of injury, the causative forces are broadly classified into blunt trauma and penetrating trauma. Common causes of blunt trauma are road traffic collisions, falls and recreational or sporting accidents. The result is most often compression, shearing, tearing or splitting of structures or vital organs. Penetrating trauma, on the other hand, results from the transfer of high kinetic energy by an object with a tapering edge that penetrates the body due to the velocity of impact. The object then travels through the body until apprehended by a decelerating force, causing injury to tissue in its path. Discharged ammunition, stabbings and impalement are examples of penetrating trauma (Eaton, 2005:16-32).

2.2.6 Suspected Spinal Injury

Injury to any part of the spinal cord or spinal column may result from the initial assault of trauma. Secondary injury to the spinal cord may ensue as a complication of unstable fractures in the spinal column, swelling and hypoxia. Regardless of the aetiology, structures involved or severity, spinal injury can only be confirmed and defined by radiological imaging (Connor et al., 2013:146). Until such imaging can occur, deductions on patterns of injury are made based on mechanism of injury (Eaton, 2005:15).

Suspected spinal injury, as the term suggests, describes a potential presentation of spinal injury. This inference is made by a healthcare practitioner based on knowledge of the likely pattern of injury produced by the kinetic force and the nature of the impact endured by the patient. The American College of Surgeons (2018:130) advocates that all trauma patients with multiple injuries be treated with a high suspicion of spinal injury. Precautionary interventions are advocated to protect the potentially injured spine until such an injury can be excluded via imaging, an investigation often delayed until life-threatening problems have been adequality managed (The American College of Surgeons, 2018:142). Until imaging can commence, and spinal injury is confirmed or excluded, suspected spinal injury is used as a provisional diagnosis in relevant trauma cases.

2.2.8 Patient Outcome

Regardless of the setting or speciality, the ultimate goal of nursing is to improve the overall health of the individual, family or community (Grove et al., 2013:11). With the intention of bringing about a positive change in the condition of the patient, nurses rely on elements in the internal and external environment to implement interventions that will produce the best outcome (Reising, 2016:667). Retrospective evaluation of the outcome forms an empirical measure to assess the achievement of this goal (Jones, 2016:np).

As the outcome is necessary to establish the value of nursing care delivered, Donabedian's Structure-Process-Outcomes model seems the most appropriate

framework to understand the concept. Although the model is designed specifically to measure the quality of health care, it provides a logical explanation of the term 'outcome'.

The model recognises three components in the delivery of health care, namely structure, process and outcome. Structure refers to the context in which care is delivered, and the process is the interaction between the healthcare user and the healthcare provider. Outcome is generally considered the most important element of the model because it relates directly to the patient and reflects the preceding components.

The outcome is the endpoint of care and is defined as the effect of health care on the healthcare user (Jones, 2016:np). Simply stated, the outcome is the condition of the patient following the intervention. It is the impact that the care has on the patient. Figure 2.1 illustrates Donabedian's theory in relation to this review.

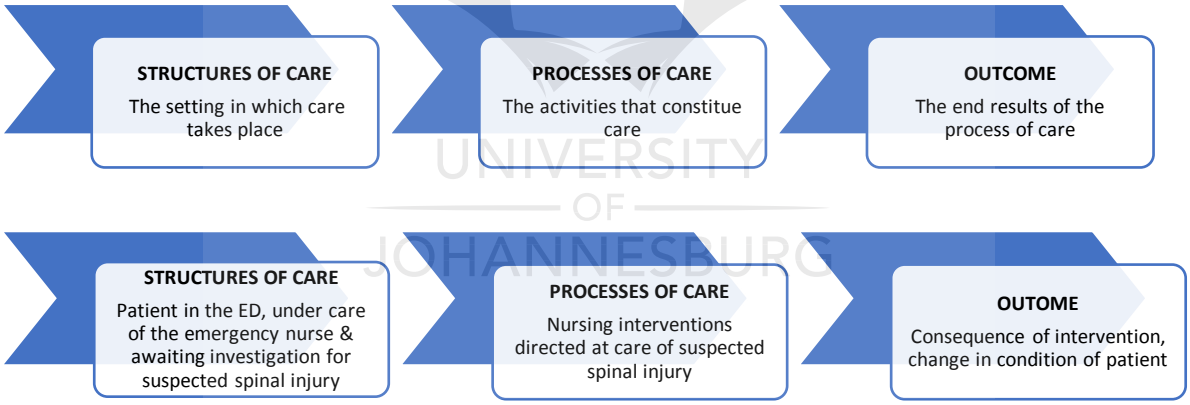


Figure 2.1: Donabedian's Structure-Process-Outcome Model (Jones, 2016:np)

2.2.9 Evidence-Based Care

As a beneficial outcome is the aspiration of nursing, evidence-based care is fundamental to the discipline (Jones, 2016:np). Evidence-based practice is a process that involves structuring a question, systematically searching for evidence and guidelines, critiquing the validity and reliability of the evidence, integrating the evidence with patient needs and values, and finally evaluating the outcome.

With a global drive towards evidence-based healthcare, nursing interventions are ideally founded on best research evidence, integrated with knowledge and skill and centred around patient needs and values (Grove et al., 2013:11).

Evidence-based care is of value to the patient, the healthcare system and the nurse by equipping all parties to develop realistic goals and to make informed decisions regarding the most appropriate intervention to produce the best outcome (Eizenberg & Mashiach, 2010:34).

2.3 LITERATURE REVIEW

2.3.1 Emergency Care in South Africa

Five hundred and forty-four hospitals, distributed across nine provinces, serve the population of South Africa. Of this total, 217 are private facilities and 327 are provincial hospitals (Dell & Kahn, 2017:1100). Located at every provincial acute care hospital is an emergency centre, also commonly known as an emergency department (Hardcastle, Oosthuizen, Clarke & Lutge, 2016:180). 'Emergency centre' is the term officially used by the South African Department of Health to describe an area in the hospital dedicated to emergencies. At government hospitals, these areas perform at different degrees of capability depending on the level of the hospital (district, regional or tertiary), which is determined by the Department of Health and usually based on the needs of the geographical location and available resources (Dell & Kahn, 2017:110).

A trauma centre is an emergency centre with a focus on providing definitive trauma care that has been accredited according to the criteria of the Trauma Society of South Africa (TSSA). Consequently, all trauma centres are emergency centres, but not all emergency centres are trauma centres (Hardcastle et al., 2016:180).

While scant information exists on the precise number of private trauma centres in the country, it is reasonable to suggest that most private hospitals are equipped with an emergency centre. However, the service provided at these facilities is limited to those who can self-fund the care provided. This group represents a minority and the

reality of the burden that health facilities carry is highlighted by Dell and Kahn's (2017:1099) calculation of one hospital and 187 hospital beds per 100 000 of the population. When the private sector is removed from the equation, those without medical aid are served by 0.7 hospitals per 100 000.

Irrespective of government funding or accreditation by the TSSA, emergency centres in all nine provinces provide care to a phenomenal number of trauma victims daily. Described as a 'malignant epidemic' (Lutge, Moodley, Tefera, Sartorius, Hardcastle & Clarke, 2016:138), trauma is defined as physical injury inflicted by intentional or unintentional means, and major trauma is defined as injuries that require definitive care beyond the emergency centre such as surgery or admission (Hardcastle et al., 2016:180).

2.3.2 The Burden of Trauma

The burden of trauma is a phenomenon that describes emergency care in South Africa in crises due to a disparity between available resources and an enormous volume of trauma (Hardcastle et al., 2016:180). Descriptive demographic data collected over the last decade for the purpose of planning and resolution provides an illustration of the problem. An assessment of emergency centre admissions at all provincial hospitals in KwaZulu Natal tallied 124 000 trauma-related emergency centre visits for the year 2010, with 80% of these being major trauma (Hardcastle et al., 2016:181). These studies later led to a data capture tool for the province, which more accurately recorded a total of 197 219 trauma visits between 1 April 2013 and 31 March 2014 (Lutge et al., 2016:13). This figure constitutes 27% of all emergency admissions and 18 716 (9.5%) required in-patient admission (Hardcastle et al., 2016:182). This information was extrapolated to calculate that 17 per 100 of the population seek trauma care every year (Lutge et al., 2016:138). With a population of 10 million and a density of 110 people per km² (Lutge et al., 2016:136) KwaZulu Natal contains more than one-fifth of the population and data taken from a 20% sample is therefore considered statistically relevant to make inferences regarding the national burden (Hardcastle et al., 2016:180).

A prospective surveillance study was conducted for emergency centre admissions at Groote Schuur Hospital in the Western Cape, which is an accredited trauma centre. Nine thousand two hundred and thirty-six trauma visits were recorded between 1 October 2010 and 30 September 2011 (Nicol, Knowlton, Schuurman, Matzopoulos, Zaragan, Cinnamon et al., 2014:549-550). This total represents one out of 40 public hospitals in the province (Dell & Kahn, 2017:1102), providing only a hint of the enormity of the problem.

In the Eastern Cape, transport accidents are responsible for 11.6% of unnatural deaths while assault-related deaths account for 15.7%. The inequity between needs and resources in this province resulted in pre-hospital emergency services attending 3.3% of calls within an hour, a load later lightened by the purchase of 150 new emergency service vehicles in 2014 (John & Matshoba, 2015:500).

Beyond this description, an online search revealed limited information detailing trauma volumes in other provinces. Nevertheless, data in these injury-related demographic studies highlight the burden of trauma in South Africa, a low-middle income country (LMIC). Trauma has been labelled a global problem among LMICs and a recurring sentiment in literature describes it as the leading cause of death and disability globally. Responsible for more than five million deaths annually, trauma trumps in mortality over the human immunodeficiency virus, malaria and tuberculosis combined (Nicol et al., 2014:550).

2.3.3 The Role of the Emergency Nurse

A 2016 health report discusses contributing factors and possible solutions to the burden of trauma in South Africa. While financial provision and adequate infrastructure are essential for service delivery, human resources are the backbone of an effective trauma care system. Poorly staffed emergency departments lead to delays in acute and definitive care, causing a ripple effect of complications resulting in a longer length of stay and increased mortality. Furthermore, the report highlights that a profession of nurses with training in trauma and emergency care is lacking in South Africa (Hardcastle et al., 2016:182).

Estimates of adequate staffing levels for tertiary government emergency centres were stipulated in the health report and are based on standardised formulae applied to provincial hospitals. The recommendation is that registered nurses (RN) with specialised training in trauma and emergency are required at a ratio of one RN per resuscitation bed and one RN for every five non-resuscitation patients, along with the assistance of enrolled nurses (EN) at a ratio of three ENs per 10 patients (Hardcastle et al., 2016:182).

Unfortunately, this ideal picture is not the reality. As is the case across the whole continent, there is an insufficient number of nurses to meet the health needs of the South African population (Brysiewicz, 2011:3). In addition, the profession of emergency nurses is an emerging field in the country with post-graduate diplomas being developed over the last decade. This presents a further challenge as there remains a limited number of specialised emergency nurses nationwide (Brysiewicz & Bruce, 2008:129).

Despite these difficulties, nurses working in emergency centres around the country remain the foundation of the workforce and continue to provide care despite the challenging environment in which they find themselves (Brysiewicz, 2011:3).

2.3.4 Nursing Management of the Acute Trauma Patient

Within the context of extraordinary volumes of trauma, emergency nurses care for patients of all ages in the acute phase of undiagnosed injury who require stabilisation and investigation. Care is delivered by determining the severity of trauma through an assessment of the patient and using critical thinking to prioritise patient-specific and evidence-based interventions. As a member of the multi-disciplinary team, the emergency nurse renders resuscitative measures and appropriate care while providing information and emotional support to patients and families (Emergency Nurses Society of South Africa, 2012:2).

A standard approach to initiating the nursing process for the injured patient involves a primary survey followed by resuscitative measures based on this assessment. The

acronym ‘ABCDE’ forms the structure of the primary survey as the nurse assesses airway, breathing, circulation, disability and exposure (Laskowski-Jones, 2009:36).

This systematic approach is advocated for being lifesaving as it prioritises life-threatening conditions identified in the primary survey based on physiological impairment rather than anatomical injury. For example, securing a compromised airway with an endotracheal tube will take precedence over managing the physical injury that caused the airway compromise (American College of Surgeons, 2018:7). Specific management of anatomical injuries, whether serious or minor, are dealt with following the secondary survey and once the immediate threats to life have been stabilised (Laskowski-Jones, 2009:36).

A secondary survey based on a head-to-toe assessment follows the primary survey and aims to identify all injuries. It therefore forms the assessment of the nursing care plan (Curtis & Ramsden, 2011:1159).

2.3.5 Suspected Spinal Injury in The Trauma Patient

The first step in the primary survey of the trauma patient is the assessment of airway patency. In keeping with the principle of prioritised assessment and management, this step includes simultaneous management of airway compromise. Literature discussing this widely used methodology includes – under ‘A’ – assessment of the mandible, larynx and trachea for injury while protecting the cervical spine (The American College of Surgeons, 2018:7). Emergency healthcare providers are taught to assume the presence of a spinal injury in all trauma victims until proven otherwise (Curtis & Ramsden, 2011:1148). Cognisance of a suspected spinal injury is highlighted as a priority of the initial step in the primary survey to prevent complications occurring during the course of management (Curtis & Ramsden, 2011:1138).

The traditional paradigm of trauma care is to immobilise the entire spine of all patients presenting with multiple injuries (Curtis & Ramsden, 2011:1298). Spinal precautions directed at the protection of suspected spinal injury are implemented to achieve this common goal of preventing spinal motion. Interventions include manual

in-line immobilisation, the jaw-thrust manoeuvre, the log-roll, and the use of external immobilisation devices such as hard neck collars and head blocks (Laskowski-Jones, 2009:36-38). These precautions are advised to be maintained until radiographical investigations have excluded a spinal injury (The American College of Surgeons, 2018:7). Management of this presumed anatomical injury is therefore delayed until the primary survey and resuscitative interventions have been completed, and only then is immobilisation terminated.

Based on a belief that these spinal immobilisation interventions are harmless (Abram & Bulstrode, 2010:219), it seems logical to implement them in support of the principle of prioritising immediate life-threatening conditions over serious disabling injuries (Laskowski-Jones, 2009:36). However, the last decade has seen significant research that discredits the notion that spinal immobilisation is harmless (Hood & Considine, 2015:119).

2.3.6 Spinal Immobilisation for Suspected Spinal Injury

Recent research conducted by the pre-hospital community has been directed at establishing evidence-based guidelines for the care and transport of trauma patients with suspected spinal injury (Hood & Considine, 2015:119; Oteir et al., 2015:528; Kornhall et al., 2017:7; Stanton et al., 2017:4-8). A brief overview of this evidence provides a summary of what is already known on the topic.

Hood and Considine (2015:118-119) systematically reviewed literature to consider the evidence regarding spinal immobilisation in the pre-hospital context. Following scrutiny and synthesis of 47 relevant articles, the conclusion drawn was that there is no high-level evidence that accurately rates the efficacy of spinal immobilisation. Trials conducted on cadavers and healthy volunteers made up a large proportion of the sample for this review, implying the practice is based on extrapolated data. Furthermore, significant evidence reporting adverse effects from spinal immobilisation was revealed by the study.

A systematic review by Oteir and colleagues (2015:528-535) queried the necessity of immobilisation when a cervical spine injury is suspected. This review also concluded

a lack of high-level evidence to support interventions directed at spinal immobilisation. Due to this paucity in information, a definitive answer to the research question was not reached. While the authors advise spinal immobilisation to be avoided in penetrating trauma, they highlight an urgency for prospective trials to address the controversy regarding spinal immobilisation in blunt trauma.

A recent Norwegian guideline for pre-hospital management of suspected spinal injury is based on a consensus and a systematic review of relevant studies. Traditional spinal immobilisation is upheld for trauma patients with suspected spinal injury. However, a more selective approach is encouraged based on the evidence of adverse effects from external immobilisers (Kornhall et al., 2017:7).

A South African guideline regarding the use of cervical collars in the pre-hospital setting deemphasises the need for spinal immobilisation in all trauma patients. Appropriate interventions based on the clinical presentation of the patient is advocated to avoid unnecessary harm. Based on a structured review of literature, the use of cervical collars is not recommended, and the principle of minimal handling is promoted (Stanton et al., 2017:4-8).

In summary, a review of literature outlines accepted conclusions regarding the topic. The practice of traditional spinal immobilisation with a long backboard, head blocks and cervical collar for all trauma patients is based on weak evidence. Research has demonstrated adverse effects of spinal immobilisation. Further robust prospective trials are required to resolve the uncertainty regarding the necessity and efficacy of spinal immobilisation.

2.3.7 The Log-Roll

The reviews discussed provide an outline of what is known on the topic of spinal immobilisation. While much of the research has been conducted with paramedics in mind, emergency nurses can benefit from the literature by applying fundamental principles to their practice. That said, the log-roll, an intervention frequently used by emergency nurses, is not addressed in the earlier description and therefore warrants reflection.

The Emergency Nurses Association (ENA) provide an evidence-based overview of this topic (Benolken, Gilbert, Tackett & Vessely, 2016:1). Advocated in the ATLS® course (The American College of Surgeons, 2018:143), the log-roll has been the mainstay of movement and transfer of the trauma patient since it was first described in 1967 as effective in stabilising the spine while the patient is in motion.

Implementation involves one member of the team stabilising the cervical spine by means of manual in-line stabilisation while another two or three people turn the patient to a lateral 90-degree position (Benolken et al., 2016:2). This methodology, rarely taught in formal training and usually learnt in practice by watching and following (Rowell, 2014:32), requires coordinated timing and is generally awkward for all involved. Furthermore, the varying sizes and proportions of the head, shoulders, torso, hips and legs make it virtually impossible to maintain the intended alignment of the spine when the human body is rolled onto its side (Benolken et al., 2016:2).

Primary research has documented that the log-roll generates rotational movement of the spine and may therefore worsen an unstable spinal fracture. This suggests that the maneuverer may, in fact, trigger the problem that it is expected to avert (Prasarn, Horodyski, Dubose, Small, Rossi, Del Zou et al., 2012:940-941). Further motivation to abandon the practice lies in the adverse effects that rolling a trauma patient is likely to cause. Severe pain, clot disruption, exacerbation of pelvic and long bone fractures and an altered haemodynamic status are all documented pitfalls to the log-roll (Rowell, 2014:32).

In addition to being detrimental for the patient, the ENA discusses the musculoskeletal injuries that log-rolling causes in healthcare workers at length. Occupational injuries such as these usually cause economic ramifications for the individual as well as for the healthcare system (Benolken et al., 2016:2).

Despite the obvious futility and harm, the log-roll remains a common means to palpation and assessment, pressure care and repositioning of the trauma patient in South African emergency centres. Although there are situations where a log-roll is feasible, such as repositioning a prone patient or protecting the airway from

aspiration when suction is unavailable (Rowell, 2014:33), the ENA recommends alternative methods of movement and transfer in every other situation. The Lift-and-Slide, the 6-Plus Lift-and-Slide, the Straddle Lift-and-Slide, and the use of assistive devices are suggested as safer and more effective methods of maintaining spinal stabilisation when it is necessary to move a trauma patient (Benolken et al., 2016:3-6).

2.3.8 Evidence-Based Care

Evidence-based nursing is well defined in literature and involves assimilating new evidence produced by exemplary research with what is already known. The goal of evidence-based nursing is to provide care that results in the best possible outcome and can therefore not be developed without considering the needs and desires of the patient (Gray et al., 2017:11).

This drive is a shift from the traditional system of expert-driven care that bases decision making on knowledge, intuition and tradition. Knowledge is gained by learning theories and pathophysiologic rationales in nursing school, together with years of clinical experience and finding what works through trial and error. While all this is valuable, research is being produced at such an explosive rate that new scientific information comes to light almost daily. Although a nurse may be an expert in a specific field, there will always be a disproportion between knowledge and scientific evidence resulting in a situation where an expert may quickly become out of date on best care (Holly et al., 2012:4).

The solution to this disparity lies in evidence-based nursing – a concept that systematically and scientifically distinguishes that which produces positive outcomes from that which is harmful or ineffective. Equipped with knowledge and evidence, nurses can make decisions regarding which intervention to choose that will best benefit the patient (Holly et al., 2012:4).

With a goal of developing and strengthening emergency nursing in South Africa, the Emergency Nurses Society of South Africa (ENSSA) was established in 2009 (Brysiewicz, 2010:2), and providing evidence-based practice guidelines is one of the

core aims of the organisation (The Emergency Nurses Society of South Africa, 2017:ENSSA Special Interest Groups). While ENSSA works towards advancing the profession through research and guideline development, there remains a gap in standards of practice, based on evidence and specific to the South African nursing environment, to guide emergency nurses caring for suspected spinal injury (Wolf et al., 2012:176).

With emerging evidence regarding the assessment and management of spinal injury in trauma, the topic remains an important one. Emergency nurses need not overlook the impact that trauma can have on mortality and disability in the form of spinal injury. The fear of missing a spinal cord injury that later causes disability is legitimate among emergency care providers, nurses included (Hauswald, 2013:720). When spinal cord injury does occur, negative implications can affect the injured individual, as well as the families and communities involved. The loss of mobility that results leads to dependence on carers for basic activities, a marked decrease in quality of life, and sometimes even loss of employment. The potential personal, social and economic challenges are therefore significant and devastating (Phillips, Braaf & Jospeh, 2018:1051).

No scientific knowledge exists regarding the degree of movement that will cause secondary neurological damage in an existing spinal injury. In light of this, movement of the trauma patient should be kept to a minimum (Prasarn et al., 2012:941). However, based on the principle of non-maleficence (Curtis & Ramsden, 2011:37), emergency nurses are obligated to do so without causing harm to the patient. An integration of best research evidence regarding spinal immobilisation, with expert knowledge and skill, would keep both the nurse and the patients safe by facilitating the provision of the highest quality and most cost-effective care possible (Chrisman, Jordan, Davis & Williams, 2014:8).

2.4 CONCLUSION

Emergency nursing interventions, blunt and penetrating trauma, suspected spinal injury and patient outcomes are constructs in the research question that were discussed. Operational and conceptual definitions of these terms promote a rigorous

design through transparent reporting and avoiding bias. Furthermore, the definitions will cement boundaries for the advancement of an effective search strategy and focus applicable eligibility criteria. Chapter Three describes the research methodology followed in undertaking this systematic review.

CHAPTER THREE
METHODOLOGY AND PILOT STUDY

3.1 INTRODUCTION

Evidence-based practice is a practical means of providing the highest quality of care to a patient. It involves employing learned knowledge and skill to deliver care that is founded on the best research evidence. The process also considers the preferences and values of the patient when making decisions (Oh, 2016:89). Evidence-based care is therefore dependant on the summary of knowledge generated by high-quality evidence (Aromataris & Pearson, 2014:3). High-quality evidence is generated by rigorous research. Fundamental to the principle of rigour is compliance with standardised methodology (Hopp & Rittenmeyer, 2015:1365).

In aiming for credible results, this study was conducted based on an accepted scientific process of systematically reviewing evidence. This chapter defines and describes this methodology.

Guidance from the Centre for Reviews and Dissemination (2009:24, 29) suggests a pilot study of various stages in the review process. To test the feasibility of the proposed methodology, this advice was followed. The research ability of the

question, eligibility criteria, search strategy, availability of relevant studies, and data extraction were elements of the method that were tested. In addition to providing an outline of methodology, this chapter briefly discusses elements of the pilot study.

3.2 RESEARCH DESIGN

3.2.1 Definition of Quantitative Research

The absolute goal of the research is to test the accuracy of perceived reality. Various research paradigms exist to fulfil this aim, of which quantitative research is but one. Quantitative research uses traditional and objective methods that are governed by strict rules to measure relationships between and among variables (Gray et al., 2017:3). Quantitative research produces results that are numerical and can, therefore, be statistically analysed to reach a conclusion or answer a research question (Tufanaru, Munn, Aromataris, Campbell & Hopp, 2017:3.1, para.1).

3.2.2 Characteristics of Quantitative Research

Quantitative research is deductive by nature and grounded in positivism. Positivism is a philosophical standpoint that recognises truth as absolute and discoverable through intentional enquiry that requires objective observation. Quantitative researchers accept the position that any deviation from objective measurement risks influencing the results of the enquiry, thereby introducing bias and muddying the truth. Fundamental to the philosophy of quantitative research is the minimisation of bias, which is done by strict adherence to rigid rules governed by the methodology (Grove et al., 2013:143).

3.2.3 Categories of Quantitative Research

Quantitative methodology is broadly categorised into three groups, with various sub-groups under each main category. The three main categories are experimental (randomised controlled trials), quasi-experimental and observational designs. Randomised controlled trials are further subdivided into crossover trials and cluster trials. Quasi-experimental research includes non-randomised controlled trials before and after studies, and interrupted time series. Observational research encompasses

cohort studies, case-control studies and case series (Centre for Reviews and Dissemination, 2009:11).

The results of experimental studies are generally considered to be the most accurate as the methodology is characteristic of the greatest control and therefore perceived to have the least risk of bias. Manipulation of the intervention, control of extraneous factors and random allocation to groups are defining features of experimental designs (Grove et al., 2013:244).

Quasi-experimental designs differ from experimental designs in that there is no random allocation of participants to groups. However, manipulation of the intervention and controlled conditions characterise the method (Tufanaru et al., 2017:3.1, para.5).

An observational research method allocates participants to the study based on the incidence or absence of exposure to the intervention under investigation. There may be one or more groups in the study, and the outcome that the intervention has on participants is directly observed. Although there is no manipulation or control in this design, the intervention and outcome are generally observed without interference, and in this way, bias is minimised (Tufanaru et al., 2017:3.1, para.6).

Systematic reviews may include any research paradigm, depending on the objectives and research question being addressed. Systematic reviews of quantitative research may focus exclusively on only one methodology; for example, reviews of effectiveness usually include only randomised controlled trials. Other types of reviews may include quantitative research of various methodologies (Holly et al., 2012:16).

3.3 RESEARCH METHOD

3.3.1 Definition of a Systematic Review

A systematic review is a summary of a comprehensive range of primary research related to a specific topic. It is the product of a systematic process of identifying, appraising and synthesising evidence. Systematic reviews aim to encapsulate the large quantity of knowledge surrounding a research question to provide an accurate

and reliable conclusion that can be translated into practice. The aim is therefore to find all that there is on a given issue through a structured and rigorous methodology (Aromataris & Munn, 2017:1.1, para 1).

3.3.2 Characteristics of a Systematic Review

Systematic reviews are considered to be among the best quality research, and therefore offer the highest level of evidence (Gray et al., 2017:32). The comprehensive and conclusive nature of the design (Rodseth and Marais, 2016:31), as well as the replicable methods and transparent reporting (Oh, 2016:90) is what places the systematic review in this esteemed position.

Several distinguishing characteristics of a systematic review aim to minimise the risk of bias and reduce the chance of inaccurate results (Aromataris & Munn, 2017:1.1, para 4). The features that define a systematic review are as follows:

- Clearly stated objectives and a well-formulated research question;
- Eligibility criteria established prior to commencement of the search and study selection;
- A systematic and broad search strategy that aims to capture all the relevant literature;
- Quality appraisal of included studies to identify the risk of bias, strengths and weaknesses of the study;
- A structured data analysis and systematic synthesis of data extracted from included studies; and
- Transparent and structured presentation of methods followed and results (Aromataris & Pearson, 2014:54).

3.3.3 Standards of a Systematic Review

Following a long history leading up to the formal synthesis of evidence, the Cochrane Collaboration was established in 1992 by Sir Iain Chalmers. To facilitate informed decision making, the organisation set out to conduct, disseminate and maintain

systematic reviews of randomised controlled trials on the effects that interventions have on healthcare (Clarke, 2015:Cochrane Collaboration, Para.5). Since then, other organisations that conduct large scale systematic reviews by teams of experts have been established. Examples of such organisations include the Joanna Briggs Institute (JBI) and the Centre for Reviews and Dissemination (CRD) at the University of York (Aromataris & Pearson, 2014:55). In addition to conducting and disseminating research, authorities such as these also develop standards and rules for performing systematic reviews and provide training in these methods (Centre for Reviews and Dissemination, 2009:iv; Aromataris & Pearson, 2014:58; Askie & Offringa, 2015:404).

With the progression of evidence synthesis, other types of systematic reviews have been developed, such as reviews of experience or meaningfulness, reviews of prevalence or incidence, and scoping reviews, to name a few (Aromataris & Munn, 2017:1.1, para.5). Guidance on accepted methodology has been drawn on from a range of sources, including but not limited to the JBI Reviewer's Manual (Peters et al., 2017:Chapter 11), the Cochrane Collaboration (Higgins et al., 2019), the CRD (Centre for Reviews and Dissemination, 2009) and the book 'Doing a systematic review; a student's guide' (Boland et al., 2014).

With the aim of establishing and maintaining a high standard for reporting systematic reviews, the PRISMA statement provides a checklist and a flow diagram for transparent reporting of methods and results. While PRISMA has been designed explicitly for reviews of randomised controlled trials, the checklist can be used as a foundation for reporting other types of reviews (Moher et al., 2009:265). The guidance provided by PRISMA was used to ensure acceptable standards of presentation were adhered to in this report.

3.3.4 The Process of a Systematic Review

The accepted steps in the systematic review methodology are standardised and explicit (Rodseth & Marais, 2016:32). The Joanna Briggs Reviewer's Manual provides an outline of the necessary process, regardless of the type of review or research question (Aromataris & Munn, 2017:1.1, para.6). While the fundamental

steps in the process remain the same, the approach will vary depending on the type of review question (Holly et al., 2012:16). The steps follow:

1. Structure a research question
2. Establish eligibility criteria
3. Identify primary research through systematic searching
4. Elect primary research based on eligibility criteria
5. Critically appraise the quality of included studies
6. Extract data from included studies
7. Systematically analyse and synthesise data
8. Interpret and present synthesised results

In addition to the steps outlined above, the JBI highlights that a protocol that is written prior to the commencement of the systematic review is a necessary addition to the outlined steps. A protocol that declares pre-established aims and methods encourages transparency and minimises bias (Aromataris & Munn, 2017:1.1, para. 7).

3.4 RESEARCH PROTOCOL

3.4.1 Definition and Significance of a Research Protocol

A research protocol details a deliberate and pre-determined plan for the research study (Gray et al., 2017:620). Described as critical to transparency, a protocol provides a blueprint of the aims and objectives as well as the methodology to be followed (Ahn & Kang, 2018:105).

In addition to being an invaluable source of preparation, a protocol contributes to managing the risk of bias in a systematic review. Protocol development involves making critical decisions prior to commencement of the study, which reduces the possibility of basing decisions on what emerges during the review process (Higgins, et al., 2019:1.5, para.1).

3.4.2 The Research Protocol for this Systematic Review

As required by the University of Johannesburg, a research proposal was submitted to the Faculty of Health Sciences in preparation for this study. The proposal provided a brief background to the topic of interest and a rationale for undertaking the review. The aims and objectives were established, as well as the design and methodology. In addition, ethical considerations and the core principles of reliability and validity were discussed. The proposal, submitted in November 2017, was accepted by the relevant bodies from the faculty (Addendum A and B).

3.4.3 Differences Between the Protocol and the Review

The protocol proposed that the research question would be structured based on the PICO (population, intervention, comparison, outcome) acronym. In addition, a plan for a meta-analysis using the RevMan Software was proposed. These are two details that differ in the review.

As the review was conducted by a novice researcher, the process proved to be somewhat iterative with much of the methodology being learnt along the way. The value that a well-formulated research question brings to a rigorous review was not fully understood at the protocol stage.

During the structuring of Chapter One of this dissertation, the research question was refined, and the PICO format was found to be incongruent with the aims and objectives of the review. The PCC (population, concept, context) format, suggested by the JBI (Peters et al., 2017:11.2.2, para.2), was therefore used instead. This alteration from the protocol did not change the fundamental objectives of the review. Eligibility criteria were pre-determined and driven by the review question.

The RevMan Software is specific to Cochrane reviews and is therefore designed to accommodate reviews of randomised controlled trials. As this review was neither a review of effectiveness nor comprised of randomised controlled trials only, Revman was not used. A statistician was consulted regarding statistical analysis and synthesis of results. A meta-analysis was deemed impossible based on heterogeneity of included studies.

3.5 RESEARCH QUESTION

3.5.1 Definition and Significance of the Research Question

Systematic reviews answer questions (Centre for Reviews and Dissemination, 2009:6). The question is addressed in the existing body of literature (Aromataris and Pearson, 2014:55), so to speak, and the ideal answer provides a definitive conclusion that directs clinical practice (Centre for Reviews and Dissemination, 2009:6). Formulating the review question is, therefore, the first of the essential steps in the review methodology (Rodseth & Marais, 2016:32).

Critical to the rigour of the review is prospective development of the question. This ensures all succeeding steps are directed by the elements in the question and avoids undue interference of the results (Biondi-Zoccai et al., 2011:169). A suitable research question steers the search and selection to identify the appropriate evidence. The research question is deconstructed into concepts that are precisely defined. Conceptual definitions are used to build the eligibility criteria and search strategy (Hopp & Rittenmeyer, 2015:1366).

3.5.2 Framework for a Research Question

Published guidelines regarding how to formulate a research question are dominated by the PICO framework (Rodseth & Marais, 2016:32; Ahn & Kang, 2018:105; Higgins et al., 2019:2.3, Para.2). A tightly defined population, specific intervention, comparator and explicit outcomes are generally accepted as essential components of the classic review question (Rodseth & Marais, 2016:32). As Hopp and Rittenmeyer (2015:1366) explain, this standard structure is appropriate in reviews determining the effectiveness of an intervention. The authors of these types of reviews achieve their objectives by correlating the outcomes of two alternative interventions in the same population. Defining and distinguishing the PICO elements are therefore imperative to determining efficacy or harm (Higgins et al., 2019:2.3, para. 1).

The research question for a different type of review is better formulated by using an approach different than the typical. Formulating the question around the

phenomenon of interest may be a more fitting approach for a systematic review with broader intent (Hopp & Rittenmeyer, 2015:1366). The JBI suggests the mnemonic PCC as a structure for the research question of a scoping review. PCC stands for population, concept and context, encompassing clear explication of these elements, but omitting explicit interventions and outcomes.

3.5.3 Population, Concept, Context

Establishing the effectiveness of a comparative intervention was not the objective of this review, and the PICO framework was therefore inappropriate. With the aim of identifying and examining primary literature related to interventions for suspected spinal injury, the review was explorative rather than explicitly investigative. A general goal was to provide a map of interventions that are used and the outcomes that those interventions produced. The PCC framework was therefore used to frame a question that directs the exploration of relevant primary sources that can be used as a foundation for evidence-based nursing of trauma patients with suspected spinal injury.
Based on this structure, the research question was framed as:

"What nursing interventions used in blunt and penetrating trauma patients with suspected spinal injury produced the best patient outcome?"

The population is defined as adult patients who are suspected of presenting with spinal injury following blunt or penetrating trauma. The concept or phenomenon of interest refers to emergency nursing interventions directed at the protection, care and management of suspected spinal injury that produced the best outcome for the patients. The context refers to patients who are being cared for in the emergency department prior to radiological investigation, confirmed diagnosis and transfer to the next level of care.

3.5.4 Reflection from the Pilot Study

Poor conceptualisation of constructs and a lack of clear context in the research question were limitations highlighted in the pilot study. Furthermore, implementing

the practical aspects of the proposed method revealed the question to be broad and ineffective at capturing relevant sources. To remedy these weaknesses, the research question was modified to:

“What emergency nursing interventions used in blunt and penetrating trauma patients with suspected spinal injury produced the best patient outcome?”

The addition of the term ‘emergency’ clarifies that the context of the enquiry is that of emergency nursing, thereby creating a more focused direction to pursue. In addition to modifying the research question, conceptual and operational definitions of constructs in the research question were clarified. A chapter dedicated to conceptual and operational definitions precedes this chapter. The definitions were researched and reported on after the pilot study, and as a result of a reflection on methodological limitations and are presented in the second chapter for logical flow and simplification of terms.

3.6 ELIGIBILTY CRITERIA

3.6.1 Definition and Significance of Eligibility Criteria

A defining feature of a systematic review is that included studies are selected based on stringent rules rather than on the preference of the author (Higgins et al., 2019:3.1:para.1). This is a major distinction between a systematic review and the classic literature review that includes articles based on the author’s opinion of what is relevant and important (Rodseth & Marais, 2016:31). The rules by which studies are selected are determined by the eligibility criteria.

Inclusion and exclusion criteria set clear boundaries for selecting all the sources appropriate for answering the review question (Holly, et al. 2012:18). Well-formulated eligibility criteria should be effective in capturing all that is relevant, but also sifting out that which is insignificant to the topic of interest (Centre for Reviews and Dissemination, 2009:10). Eligibility criteria are established directly from the elements in the research question. In addition to this, the criteria should stipulate what types of studies will be included (Higgins et al., 2019:3.1, para. 2).

The eligibility criteria for this review were translated from the PCC elements of the review question (Peterson et al., 2014:11.2.4, para. 1). Pre-determined criteria further detail the study design, publication period and publication language for inclusion (Ahn & Kang, 2018:105). Included studies were based on the boundaries set by the eligibility criteria, formulated before the commencement of the review. This ensured that studies were chosen based on the design, and not on the conclusion or results of individual sources (Aromataris & Pearson, 2014:55).

3.6.2 Inclusion and Exclusion Criteria

3.6.2.1 Reporting Characteristics

Types of studies: All quantitative study designs examining the management of suspected spinal injury were included. No language restrictions were imposed; however, only studies published from 2012 onwards were included. A preliminary search on the topic of suspected spinal injury revealed that significant research had been conducted recently. Relevant and up to date information regarding the concept was sought, and for this reason, the date restriction was applied.

3.6.2.2 Study Characteristics

Population: Adults, aged 12 years and older, presenting with a suspected spinal injury in the cervical, thoracic or lumbar region following blunt or penetrating trauma were included. Cadavers and healthy volunteers were also considered. Participants with a confirmed diagnosis of spinal injury were excluded. The focus of this study was on the nursing care of trauma patients in the acute phase of care, and the vast scope of nursing management in the various types of confirmed spinal injury is therefore beyond the scope of this review. Similarly, patients presenting with suspected spinal injury due to a pathology other than trauma were also omitted.

Concept: Studies examining the outcome of interventions directed towards the protection, care and management of suspected spinal injury were included. As has been explicitly stated, the concept of interest is emergency nursing care rendered to the population. Interventions directed at suspected spinal injury overlap across the disciplines that make up the multi-professional team of acute care. Studies

investigating interventions by pre-hospital and transport personnel, as well as medical personnel, were therefore included.

Context: The context of the research refers to patients under the care of emergency nurses in an emergency department. Although the environment for which evidence-based care was sought involves the in-hospital nursing discipline, a background search revealed much primary research conducted in the pre-hospital environment. To include as much relevant literature as possible, studies that focused on the phenomenon of interest within the pre-hospital and in-hospital environment where included. Primary research conducted within the context of long-term care, such as intensive care, or rehabilitation, was excluded.

The inclusion and exclusion criteria have been tabulated and attached as Addendum C.

3.6.3 Reflection from the Pilot Study

A pilot of the eligibility criteria provided an opportunity for the researcher to practice applying the boundaries of selection to identified sources. This was a valuable experience and provided some confidence regarding this aspect for the main study. The inclusion and exclusion criteria proved appropriate for selecting relevant studies. A preliminary search, done for the introduction and background of this study, suggested that much research on the topic of interest occurs within the field of pre-hospital care, rather than in the context of nursing. The pilot study produced similar findings in this regard and confirmed the advantage of including studies done in both fields in aspiring for an exhaustive search.

3.7 SEARCH STRATEGY

3.7.1 Definition and Significance of the Search Strategy

In addition to minimising bias by advanced decision making, an exhaustive and appropriate literature search is a core component of a systematic review (Holly et al., 2012:21). A well-planned strategy that is driven by the research question and captures a comprehensive body of literature from appropriate sources are

characteristics of a strong search. In addition, the search should be documented in detail to facilitate replication and enhance transparency and credibility (Oh, 2016:91). To achieve this standard of searching, a logical, systematic and stepwise approach is suggested (Rodseth & Marais, 2016:33). Keywords from the research question and synonyms for those terms are identified as a starting point. The terms are combined using Boolean logic to create search strings. Truncation and fuzzy logic may also be used where appropriate (Basu, 2017:2).

3.7.2 Proposed Search Strategy

The JBI propose a systematic strategy to ensure an appropriate and unbiased literature search is conducted. The strategy is described in three main steps. Firstly, an initial search is conducted using search terms from the review question. Papers retrieved from this search are analysed for reoccurring words in the titles, abstracts and indexed terms. The second step involves an additional search using the primary keywords as well as the terms identified in the first step. A final step in the strategy involves scanning the reference lists of identified studies. The JBI explains that this reference screen can be done on all the retrieved studies, or for only the included articles. Either way, this decision should be made in advance (Peters et al., 2017:11.2.5).

To identify as much literature as possible, Cochrane suggests searching a wide range of academic databases selected based on the topic of interest (Higgins et al., 2019:4.3, para. 1). MEDLINE is an example of a well-known database indexing medical research but would be insufficient if searched in isolation (Rodseth & Marais, 2016:33). Searching multiple databases is essential as there is not necessarily an overlap of indexed studies across topically related databases. Careful consideration should, therefore, be given to the sources searched to target appropriate and exhaustive literature (Holly et al., 2012:22).

It is widely accepted that the search should be documented and presented in the report of the review. PRISMA recommends that a full search for at least one electronic database be presented for duplication (Moher et al., 2009:266). To facilitate this, meticulous citation management using an appropriate software

program is advised. Using a software program for organising retrieved literature creates permanent storage of results list, facilitates duplicate removal, and streamlines the process of reporting the search (Holly et al., 2012:23).

3.7.3 Reflection from the Pilot Study

The three-step search strategy suggested by the JBI (Peters et al., 2017:11.2.5) was followed for the pilot study. Despite efforts to create a precise plan based on these guidelines, much of the search was exploratory. This step proved to be complicated and repetitive owing to constraints such as the broad context of the research question, and inexperience in searching an academic database. Despite the limitations, the pilot study did yield a sample of relevant studies and therefore served the purpose of establishing the feasibility of this aspect of the methodology. Figure 3.1 illustrates the search strategy for the pilot study. A full search strategy for the main study is attached as Addendum D.

The pilot study provided an opportunity to experiment with citation management as well as maintaining a record of results lists, dates of searches, total hits and the corresponding search terms and sources. Microsoft Excel was utilised for this purpose. Microsoft Access was used for citation management for the main study.

CINAHL searched via EBSCO HOST provided by the University of Johannesburg

- (nurse OR nurses OR nursing) AND trauma AND (spinal OR spine) **total hits = 63.**
- (nurse OR nurses OR nursing) AND trauma AND (outcome OR benefit) **total hits = 575**
- (nurs OR nurse OR nursing OR nurses) AND emergency AND (spine OR spinal) **total hits = 82**
- (nurs OR nurse OR nursing OR nurses) AND (spine OR spinal) AND (immobilisation OR immobilization) **total hits = 15**
- (nurs OR nurse OR nursing OR nurses) AND (spine OR spinal) **total hits = 697**
- (nurs or nurse or nursing or nurses) AND suspected spinal injury **total hits = 1**
- (nurs or nurse or nursing or nurses) AND (spinal immobilisation OR spinal immobilization) **total hits = 4**
- spinal immobilisation OR spinal immobilization **total hits = 93**
- (spinal cord injuries prevention and control) AND trauma **total hits = 14**
- suspected spinal injury **total hits = 18**
- (nurs or nurse or nursing or nurses) AND (spine OR spinal) AND (suspected OR trauma) AND (interventions or management OR care) NOT (child or paediatric or paediatric or children) **total hits its=44**

This program is suggested by the CRD (Centre for Reviews and Dissemination, 2009:21) and is preferred for its capability of creating a database of relational tables. Furthermore, the software offers easier entry of data into forms that populate information onto tables; Addendum E is an example of citation management from the Access database. In addition, all retrieved items were uploaded to Mendeley software in the pilot study as well as in the main study. Mendeley served to create a reliable and permanent record of the full search and provided valuable tools such as 'remove duplicates' and citation plugins.

Figure 3.1: Summary of the search Strategy for Pilot Study

3.8 STUDY SELECTION

3.8.1 Definition and Significance of Study Selection

A comprehensive search of multiple electronic databases will usually yield many titles, sometimes even thousands (Rodseth & Marais, 2016:33). Study selection involves choosing all the articles that are relevant to the enquiry from this list of results. It is a systematic process of elimination that should be conducted in a manner that aims for precision and avoids error (Centre for Reviews and Dissemination, 2009:23).

3.8.2 The Process of Study Selection

The first step in the process is to remove duplicates. This is often simplified by using a software program that recognises and highlights duplication of title, author and bibliographic details (Higgins et al., 2019:4.6.3, para. 2). Highlighted duplicate records can then be immediately removed from the list. Duplication of studies may also present as multiple publications of the same study. These are more difficult to identify and may slip through the initial duplicate screen. Reviewers are advised to be cognisant of this risk and be alert for common elements across studies. Examples include author, location, sample size, similar interventions, publication dates and ethical review reference numbers. In such instances, duplicates are removed or merged as they are detected (Higgins et al., 2019:4.6.2, para. 1).

The next step in the process is to read every title in the list of results. The title is considered against the pre-determined eligibility criteria and a decision is made to keep or exclude the record. The process is repeated by reading the abstract of each record that met inclusion criteria at the title screen (Basu, 2017:4). It is advisable to be over-inclusive when screening titles and abstracts (Centre for Reviews and Dissemination, 2009:23).

Finally, the full text of each potentially relevant record is scrutinised, and the details of the study are evaluated. Records that do not meet the inclusion criteria are excluded. A list of all available evidence related to the research question should remain following the full text screen (Rodseth & Marais, 2016:33).

The number of records excluded at each stage should be recorded, along with a reason for each exclusion (Basu, 2017:4). To ensure transparency, a flow diagram illustrating the process of elimination should accompany the review report (Moher et al., 2009:267).

It is generally accepted that the process of study selection should be conducted by two independent reviewers. The two reviewers should agree on every record included and excluded, and disagreements should be resolved through discussion or by a third person. Screening and selection by two reviewers reduce the risk of selection bias, thereby increasing reliability. The inter-rater reliability regarding the two reviewers may be formally assessed using statistical methods (Centre for Reviews and Dissemination, 2009:24).

Despite the consensus surrounding this two-person approach to study selection, Cochrane highlights that methodological studies have demonstrated the accuracy of a single reviewer in study selection at title and abstract phase. An independent reviewer is, however, essential for the full text screen. Furthermore, accuracy is improved if this second reviewer is not an expert on the topic of interest because selection is more likely to be based on eligibility criteria and less likely to be based on definitions and explication of the subject matter (Higgins et al., 2019:4.6.4, para. 3-4).

3.8.3 Reflection from the Pilot Study

Titles and abstract screening from the result list of one electronic database were piloted. This provided an opportunity to apply the eligibility criteria to a sample of records to test consistency and feasibility. A full text screen was not piloted, and study selection was conducted independently by the primary reviewer. No changes were made to the eligibility criteria following the pilot study. Figure 3.2 illustrates the selection process for the pilot study.

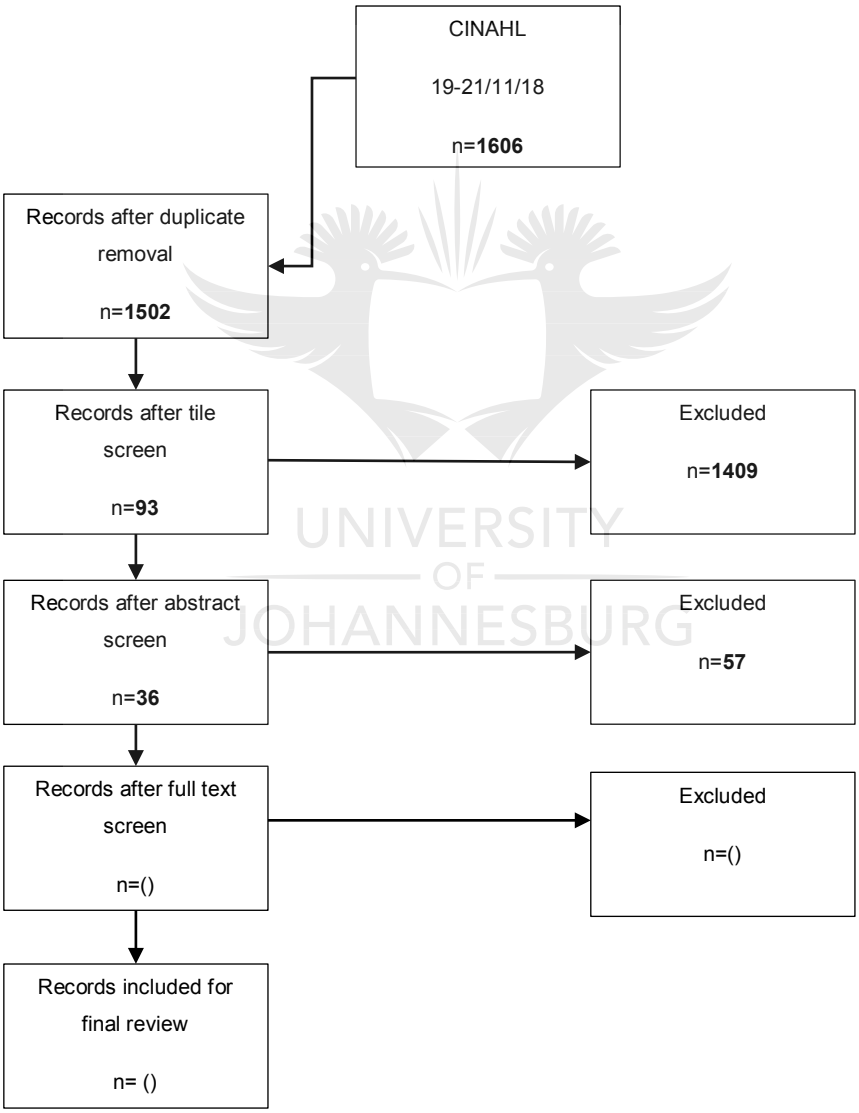


Figure 3.2: PRISMA Flow Diagram for Pilot Study

3.9 QUALITY APPRAISAL

3.9.1 Definition and Significance of Quality Appraisal

The CRD broadly describes the quality of evidence as the degree to which the findings of the research represent the truth, and whether the findings are applicable to the setting or population of interest (Centre for Reviews and Dissemination, 2009:34).

The quality of the evidence in the individual studies has a direct impact on the results of the systematic review. If the integrity of included studies is poor, then the results of the review will be compromised, regardless of the adherence to accepted methodology (Ahn & Kang, 2018:105). An assessment of the internal validity and external validity for each relevant record is therefore imperative to answering the review question (Mittal, Goyal & Mittal, 2017:321).

Some systematic reviews use the quality of studies as an element of eligibility criteria by establishing a threshold for exclusion in advance (Oh, 2016:91). However, excluding studies based on quality is not standard practice. The JBI generally exclude all studies of low quality, whereas Cochrane usually includes all relevant studies, but explicate the risk of bias in the final report (Hopp & Rittenmeyer, 2015:1367). Either way, the decision regarding this aspect should be made at protocol stage. If low-quality studies are included in the synthesis, the impact that this has on final conclusions should be discussed. Precise evaluation and reporting of quality facilitate reliability and transparency by allowing consumers to make informed decisions about the strength of recommendations (Ahn & Kang, 2018:105).

The method of quality appraisal will be unique for each systematic review and will depend on the type of review, type of included studies as well as pragmatic and logistical aspects (Centre for Reviews and Dissemination, 2009:33). It is, however, advisable to make use of a standardised and reliable tool. Furthermore, the process of quality appraisal should be performed by two independent reviewers. Both reviewers should critically appraise each article based on the same instrument, following which a consensus conversation serves to resolve discrepancy (Hopp & Rittenmeyer, 2015:1367).

The CASP checklists were used as instruments for the quality appraisal for the systematic review in this study (Addendum G, H and I).

All eligible studies were included in data analysis regardless of quality. However, the implications that the quality of included studies has on the generated evidence was discussed as part of evidence synthesis.

3.9.2 Critical Appraisal Skills Program

The CASP provides a series of domain-based checklists for design-specific quality appraisal of research articles. With over two decades of usage (CASP - Critical Appraisal Skills Programme, 2018: 'About Us'.para.2), the tools are considered valid and reliable to assess rigour, accuracy and relevance. Developed by experts and trialled by healthcare professionals, the checklists are comprised of three sections that encourage inquiry into the validity, precision and generalisability of the research (*CASP - Critical Appraisal Skills Programme*, 2018: CASP SR Checklist. para. 3-4).

3.10 DATA EXTRACTION

3.10.1 Definition and Significance of Data Extraction

Data extraction is the process of locating and documenting information pertinent to answering the research question (Oh, 2016:91). As with all the steps in the systematic review methodology, it is a standardised and structured process. Descriptive and outcome data are extracted from each individual study and recorded in a format that can be used in data synthesis (Munn, Tufanaru & Aromataris, 2014:49).

In addition to bibliographic information, data extracted from each question are guided by the elements of the research question. Information regarding the characteristics of the population, including demographics, should be collected from each study. Detail relating to the concept in the research question, as well as the context in which it was examined, should also be specified (Peters et al., 2017:11.3.7.3).

Descriptive data are essential for correlating the studies during data analysis. Furthermore, reporting descriptive data from individual studies allows readers to judge the external validity of the systematic review. Hence, extraction of information regarding study design and methodology is necessary. This includes aspects related to randomisation, blinding, sampling, data collection and data analysis (Munn et al., 2014:49-50).

Data extraction further includes identifying and recording information related to the outcomes of each included study. This may be presented as dichotomous data or continuous data. The value, as well as the summary measure and sample size, must be extracted individually so that results can be interpreted and synthesised in the next step (Rodseth & Marais, 2016:34).

A standardised tool should be used for data extraction. In addition to facilitating precision and minimising the risk of error, a data extraction form also provides a permanent record of collected data. A hard copy or electronic record of data extraction expedites both data analysis and report writing and also improves transparency and replicability (Holly et al., 2012:25). While there are various templates available, a unique form may also be developed based on the requirements of the review. Either way, the data extraction form should be proposed at the protocol stage and piloted to test for feasibility. Following the pilot, the form may be clarified and refined (Munn et al., 2014:50).

3.10.2 Reflection from the Pilot Study

A data extraction form, created using Microsoft Word, was proposed at the protocol stage and tested in the pilot study. The pilot was helpful in providing familiarity with the primary research while the sections and headings of the form demonstrated sufficiency and efficacy in organising and separating facts. However, a need for more concise extraction was highlighted. Based on this experience, two data extraction forms were used for the main study. The data extraction form in Word format was used for a narrative collection of details as this is necessary for analysis and transparency. A second data extraction instrument was created in Microsoft

Excel for the extraction of quantitative results, specifically for the descriptive statistics of primary outcomes in each study. This method facilitated the extraction of data related to outcomes and provided a visual for comparison. An example of the narrative data extraction form is attached as Addendum J. The entire Excel sheet containing statistical data extraction is too large to attach as an Addendeum. An example of statistical results collected is tabulated and attached as Addendum K.

3.11 DATA SYNTHESIS

3.11.1 Definition and Significance of Data Synthesis

A fundamental aim of a systematic review is to provide an unbiased summary of available evidence related to a specific topic (Aromataris & Pearson, 2014:54). Central to this feature is the synthesis of extracted data, which constitutes the results of the systematic review (Munn et al., 2014:49). Data synthesis is therefore the process of combining the results from included studies to arrive at an aggregated conclusion (Davis, 2016:69). There are two accepted methods for systematically synthesising quantitative research, namely a meta-analysis and a narrative synthesis (Oh, 2016:92).

3.11.2 Meta-analysis

A meta-analysis is the statistical combination of quantitative data from multiple studies to calculate a single summary of effect (Shorten & Shorten, 2013:3). When multiple single studies examining the same intervention arrive at contradictory results, it would be inaccurate to simply tally the evidence for and against the intervention to establish its effect. The inaccuracy stems from the variability in validity and reliability of results from individual studies. While this method of vote counting may provide a vague idea regarding the direction of effect, it gives no indication of the magnitude of effect (Munn et al., 2014:49). A meta-analysis, however, utilises software packages to assign each study with a weighting based on the individual effect size (Rodseth & Marais, 2016:34). The statistical pooling that results provides an overall effect size indicating both the direction and the magnitude of effect (Munn

et al., 2014:49). This provides a clinically relevant statistical summary, such as an odds ratio or number needed to treat, that has greater power and precision than an individual study (Hopp & Rittenmeyer, 2015:1363; Ahn & Kang, 2018:105-106).

While a meta-analysis is the gold standard of quantitative synthesis, it is not always possible (Munn et al., 2014:49). Statistical pooling of results can only be done if the individual studies are similar enough to combine. A meta-analysis is inappropriate if the studies are so different that it is impossible to statistically pool results (Basu, 2017:6). The term used to describe the difference across studies is 'heterogeneity'. Heterogeneity is categorised into clinical (participants, interventions and outcomes), methodological (design and methods) and statistical (effect sizes) heterogeneity. Prior to commencing a meta-analysis, included studies should be assessed for the degree of heterogeneity to determine if synthesis is possible (Askie & Offringa, 2015:406). This is generally done by means of standardised statistical tests (Munn et al., 2014:51).

Should a meta-analysis be possible and appropriate, it is generally performed by a statistician using one of two statistical methods, namely a random-effects model or a fixed-effects model. The statistical method used depends on the variability of effect sizes across included studies (Rodseth & Marais, 2016:34). The result of a meta-analysis is presented as a forest plot. Each forest plot provides a visual representation of the individual studies as well as the aggregated summary of effect for one outcome. A systematic review examining multiple outcomes may therefore illustrate multiple forest plots (Munn et al., 2014:52).

3.11.3 Narrative Synthesis

When heterogeneity of included studies inhibits statistical pooling, a narrative synthesis is an alternative method for combining the results of quantitative research (Ahn & Kang, 2018:106). While there is limited consensus regarding the methodology for this type of synthesis (Hopp & Rittenmeyer, 2015:1363), most sources agree that the process should be logical and systematic. Tables, graphs and diagrams are suggested as a means to describe core information to facilitate

analysis and comparison (Holly et al., 2012:28; Ahn & Kang, 2018:106; Peters et al., 2017:11.3.7.4).

3.11.3.1 The Economic and Social Research Council (ESRC) Methods Programme

The ESRC Methods Programme developed a guideline for the conduct of a narrative synthesis (Popay et al., 2006:5). The guideline was conceptualised by means of a systematic method and aims to establish basic elements in the process to avoid unintentional bias by highlighting the results of some studies while understating others.

While the ESRC concede that a narrative synthesis is difficult to complete and will vary greatly in every review, a broad standard aims to facilitate a systematic approach to combining non-statistical results. Guidance is offered within the context of four areas of focus. Development of a theoretical model to clarify the comprehension of the investigation is suggested as an optional but helpful step in narrative synthesis. Preliminary synthesis serves to identify relationships and patterns between included studies. Exploring the nature of these relationships is then suggested before finally assessing the robustness of the synthesis (Popay et al., 2006:11). This framework, suggested by the Cochrane Review Group (Ryan & Cochrane Consumers and Communication Review Group, 2013:3) and the CRD (Centre for Reviews and Dissemination, 2009:48), was used as a guideline for narrative synthesis in this review.

3.12 CONCLUSION

A structured and standardised process that dictates rules for conduct aims to minimise the risk of bias in the systematic review methodology. The logical steps in the process include formulating a research question based on a framework, systematically searching for literature, selecting studies for inclusion based on pre-defined criteria, establishing the quality of the evidence, and systematically synthesising extracted data. This chapter outlined the methods followed in this review and briefly discussed aspects that were piloted to test for feasibility. Chapter Four describes the application of the standardised process for systematically

reviewing literature related to interventions directed at suspected spinal injury. In addition, a brief description of included studies is presented.

CHAPTER FOUR
DESCRIPTION OF THE RESEARCH PROCESS AND INCLUDED STUDIES

4.1 INTRODUCTION

This systematic review was conducted in accordance with the standardised and accepted methods described in Chapter Three. The application of the research question and eligibility criteria were tested in the pilot study. In addition, the search strategy, study selection and data extraction were assessed for feasibility and refined.

This chapter describes the application of the research process for the main study. An initial description of included studies is also provided.

4.2 INFORMATION SOURCES

4.2.1 Electronic Databases

Six electronic databases, provided by the University of Johannesburg's library interface, were canvassed between April 3rd and April 6th, 2019 to identify studies reporting on the emergency management of suspected spinal injury. CINAHL, MEDLINE, SAGE and Academic Search Ultimate were systematically searched for

articles published from 2012 onwards. Sabinet was also searched to ensure the inclusion of any relevant articles that may have been conducted in South Africa and Africa.

4.2.2 Reference Lists

The reference lists from studies identified after a full text screen were scanned to ensure no potentially relevant research had been missed by the database search.

4.3 SEARCH STRATEGY

4.3.1 Keywords and Search Strings

The keywords ‘emergency’, ‘nursing’, ‘interventions’, ‘trauma’ and ‘suspected spinal injury’ were extracted from the research question as primary keywords. The term ‘spinal immobilisation’ was also utilised to avoid the exclusion of relevant articles not detected by keywords from the research question. A list of synonyms for each keyword was developed. Examples of synonyms include ‘possible spine injury’, ‘potential spine injury’ and ‘spinal motion restriction’.

As suggested by the JBI Reviewer's Manual (Peters et al., 2017:11.2.5), subject terms used to describe the articles found in the initial search were analysed. This step revealed that the term ‘spinal cord injuries prevention and control’ was frequently used as a subject term. Accordingly, the term was also used as a keyword.

Keywords were linked using Boolean operators to form search strings that were used in the search box for each electronic database. Where applicable, wildcards and truncation were made use of and the only limiter set was date of publication.

The search strategy used for MEDLINE is illustrated in Figure 4.1, while the full search strategy for each database is attached as Addendum D.

MEDLINE searched via EBSCO Host provided by the University of Johannesburg

Emergency AND nurs* AND interventions AND trauma AND suspected spin* injury **total hits = 0**

nurs* AND interventions AND trauma AND suspected spin* injury **total hits=0**

emergency AND interventions AND trauma AND suspected spin* injury **total hits = 4**

interventions AND trauma AND suspected spin* injury **total hits = 7**

interventions AND suspected spine* injury **total hits = 9**

trauma AND suspected spin* injury **total hits = 55**

nurs* AND suspected spin* injury **total hits = 6**

suspected spin* injury **total hits = 80**

emergency AND nurs* And interventions AND Trauma AND spin* immobili?ation **total hits = 3**

emergency AND interventions AND trauma AND spin* immobili?ation **total hits = 7**

nurs* AND interventions AND trauma AND spin* immobili?ation **total hits = 2**

interventions AND trauma AND spin* immobili?ation **total hits = 10**

trauma AND spin* immobili?ation **total hits = 136**

spin* immobili?ation **total hits = 310**

possible spin* injury **total hits = 95**

spin* motion restriction **total hits = 26**

spinal cord injuries prevention and control **total hits = 33**

spin* motion AND trauma **total hits = 91**

emergency AND nurs* AND spin* **total hits = 142**

Figure 4.1: Search Strategy for MEDLINE

4.3.2 Citation Management and Duplicate Removal

The outlined searches yielded 4 767 titles from all six databases. The list of citations from the results of each search string was downloaded in BibTex format and imported to the Mendeley Reference Management Software program. The 'Check for Duplicates' tool on Mendeley was then used to identify and remove duplicates. A total of 1 962 titles were screened following duplicate removal. A further seven articles were retrieved after hand searching the reference lists of potentially relevant full text articles. This search strategy was implemented by the researcher following supervisory approval prior to commencement.

4.4 STUDY SELECTION

4.4.1 Title Screen

All titles retrieved from the electronic database search were assessed for eligibility and any article concerning interventions related to suspected spinal injury following trauma was assigned a unique identifier for the purpose of citation management. A database table, created by the researcher using Microsoft Access, was used to store the unique identifier, bibliographic data and information regarding the source and search string for each potentially relevant title. Google translate was used to translate non-English records at this stage of the study selection. Paediatric and animal studies were excluded, as well as study designs in conflict with that of the pre-determined inclusion criteria, such as qualitative research. Furthermore, concepts not relevant to the research question were also excluded; for instance, research comparing various types of intubation methods and equipment in the presence of spinal immobilisation. Following the title screen phase, 202 potentially relevant titles were added to the Access database.

4.4.2 Abstract Screen

The next phase of study selection involved reading the abstracts of all potentially relevant titles. Inclusion and exclusion criteria were applied to each abstract by the researcher. The unique identifier and bibliographic information of abstracts consistent with the eligibility criteria were then stored on a second Access database table dedicated to potentially relevant articles following abstract screening. Where a decision was difficult to make regarding relevance, the abstract was included anyway for further scrutiny at a later stage. A large proportion of articles excluded at this stage were commentaries, editorials, expert opinions or clinical discussions. One hundred and six potentially relevant abstracts were included in the second Access database for the next round of screening.

4.4.3 Full Text Screen

Following abstract screening, the full texts of all 106 potentially relevant articles were read by the researcher and details regarding the primary research were assessed for

eligibility. At this stage, a further 53 records, inconsistent with the inclusion criteria or otherwise irrelevant to the objectives of the systematic review, were excluded. Most articles excluded during this phase were rejected based on methodology; in particular, 17 structured literature reviews and five abstract only sources. Studies were also excluded based on conceptual incongruency. For example, research examining the definitive management of confirmed spinal injury, relationships between spinal immobilisation and radiological investigations, and the protection of a suspected spinal injury during extrication from a motor vehicle. In addition to these, clinical protocol validations were excluded as well as studies without an outcome measure or a human subject. Figure 4.2 provides further detail on reasons for exclusion at this stage of screening.

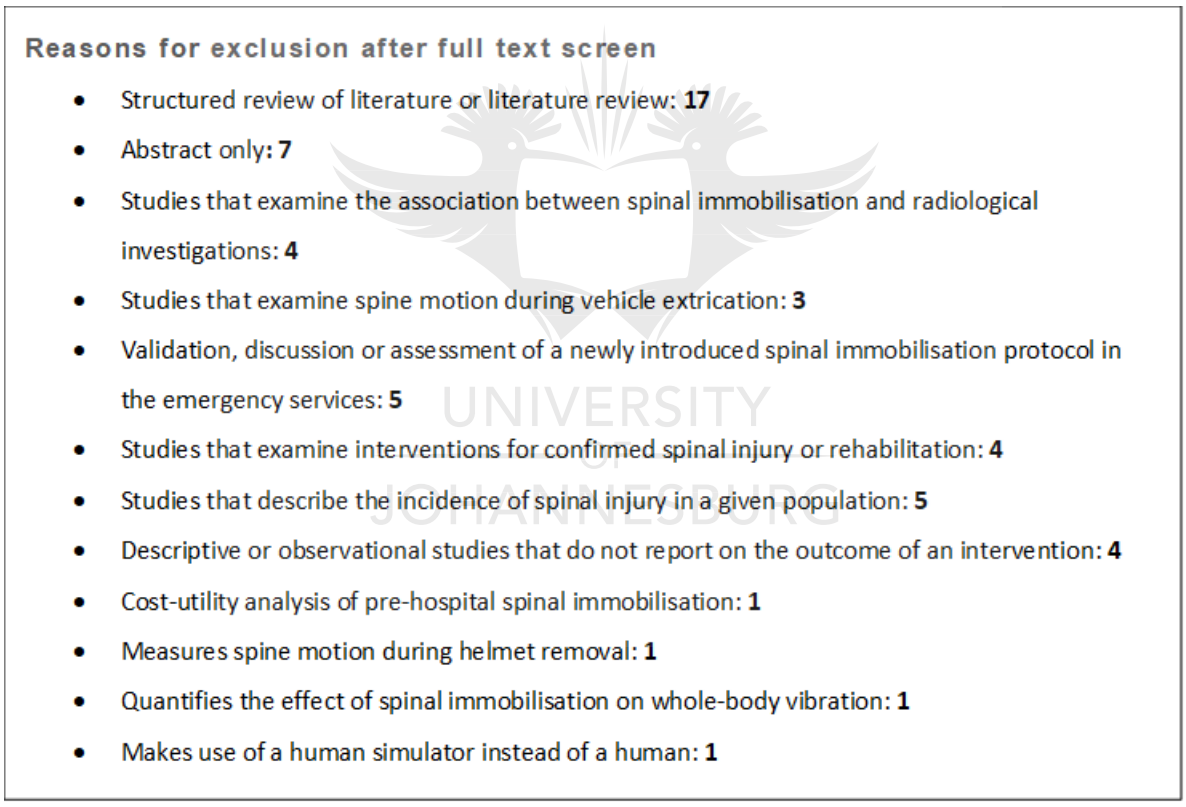


Figure 4.2: Reasons for Exclusion After Full Text Screen

During the full text screening phase, supervisory input was requested over an uncertainty regarding 28 records. Following independent assessment, agreement was established between the researcher and the supervisor regarding the eligibility of all 28 articles.

A third Access database table was created, listing the unique identifier and bibliographic details of 53 potentially relevant full text articles. At this stage, the reference list of each potentially relevant full text article was scanned for records not detected by the electronic database search leading to a further seven potentially relevant articles. The result was an Access database table containing 60 potentially relevant full text articles. The Access database is too large to add as an addendum; an example of some of the information populated is attached as Addendum E.

Subsequent to dialogue between the researcher and supervisor, this sample of potentially relevant records was established as sufficient. An additional search for grey literature was therefore deemed as unnecessarily iterative.

4.4.4 External Reviewer

Accepted standards regarding the methodology of a systematic review suggest the study selection process be completed by at least two reviewers to minimise the risk of selection bias (Davis, 2016:67). This systematic review was completed for academic evaluation as part of a Masters' degree programme at the University of Johannesburg. The search and study selection were therefore conducted by the researcher as the sole reviewer under the guidance of a supervisor from the university.

Within this context, reliability and risk of selection bias were addressed by seeking expert opinion from an independent reviewer otherwise uninvolved in the study. The external reviewer was an expert researcher, but not an expert on the topic of interest. This is a strategy suggested by Cochrane to increase the chance that study selection is based on eligibility criteria and not on subject definition and explication (Higgins et al., 2019:4.6.4, para. 4).

Eighty percent of the 60 potentially relevant full text articles were validated by the external reviewer to ensure the consistent application of inclusion criteria. In addition to this, feedback provided highlighted vague conceptual congruency between several potentially relevant articles and eligibility criteria. Variables of focus in the

primary studies, as well as critical thinking points, were also put forward for consideration in subsequent steps of the research process.

4.4.5 Final Full Text Screen

A discussion between the researcher and the supervisor concluded that a systematic review of 60 primary sources was not feasible. Therefore, 60 potentially relevant full text articles were once again interrogated for a final round of screening. Taking the comments provided by the external reviewer into consideration, each study was re-assessed, and a further 36 full text articles were excluded.

During this last stage of screening, studies were excluded if the conceptual differences in objectives were perceived to be too varied from that of the systematic review. For example, research seeking to quantify inflammatory markers or tissue damage following immobilisation were regarded impertinent. Additionally, studies exploring the vacuum mattress splint were also excluded at this stage. A vacuum mattress splint is a device intended for immobilisation of a patient with a suspected spinal injury requiring transport by road or air. The device, designed to suit this unique scenario, is almost never used in an emergency department. While research regarding the vacuum mattress splint would be valuable for nurses working in the pre-hospital and aeromedical environment, it is not generalisable to the present research question which focuses on interventions implemented in the emergency department and was thus excluded.

Similarly, 12 cadaver studies were excluded on the basis that the results lack implications for practice relevant to the research question for this systematic review. The pre-determined eligibility criteria made provision for the inclusion of cadaver studies. Therefore, this research could not be excluded based on population. Instead, the implication that surrogate outcomes would have on results was discussed between the researcher and the supervisor. Following mutual agreement, the studies were excluded because it was established that the results stipulated would not be generalisable or applicable to the nursing care of trauma patients with suspected spinal injury. The implications that this decision has on the rigour of the methodology is discussed as a limitation in subsequent chapters.

Data extraction was completed on the remaining 24 relevant articles. The detailed dissection of each article in this step revealed further reservations regarding inclusion of some of the articles. A significant overlap of included articles was found across three systematic reviews. Consequently, two systematic reviews and one cohort study were excluded to avert the introduction of bias through duplication of data.

One randomised controlled trial compared the efficacy of three specific brands of cervical collars. It could not be confirmed that the brands under scrutiny are used in emergency departments in South Africa. The questionable external validity of this study therefore resulted in its exclusion at this stage.

Finally, a cohort comparing spinal motion on a long backboard versus a scoop stretcher was excluded as the method of inquiry involved 10 healthcare professionals leading a simulation of the same healthy volunteer. The study was excluded as the sample was composed of healthcare workers and therefore incongruent with the eligibility criteria. This detail was likely missed in the earlier stages of screening as the article was published in Spanish and accurate translation only occurred immediately prior to data extraction.

Detailed reasons for the exclusion of articles excluded in the final stage of full text screening are attached as Addendum F and are briefly summarised in Figure 4.3. A flow diagram illustrating the process of study selection is presented as Figure 4.4.

Reasons for exclusion after final full text screen

- Results are not generalisable to nursing care of suspected spinal injury in an emergency department: **18**
- Concept is too varied from that of the research question: **5**
- Studies that examine the vacuum mattress splint: **5**
- Structured review of literature or literature review: **2**
- Data from one study reported on in multiple journal articles: **2**
- Validation of a newly introduced spinal immobilisation protocol in the emergency services: **1**
- Guideline based on a systematic review, but some critical aspects of the methodology are not reported: **1**
- Setting is elective surgery:**1**
- Interventions examined are not exclusively directed at suspected spinal injury, but also include confirmed spinal injury:**1**
- Inclusion of paediatric patients: **1**
- Sample consists of health care professionals rather than patients**: 1**
- Duplication of primary studies across included systematic reviews**: 3**

Figure 4.3: Reasons for Exclusion in Final Full Text Screen

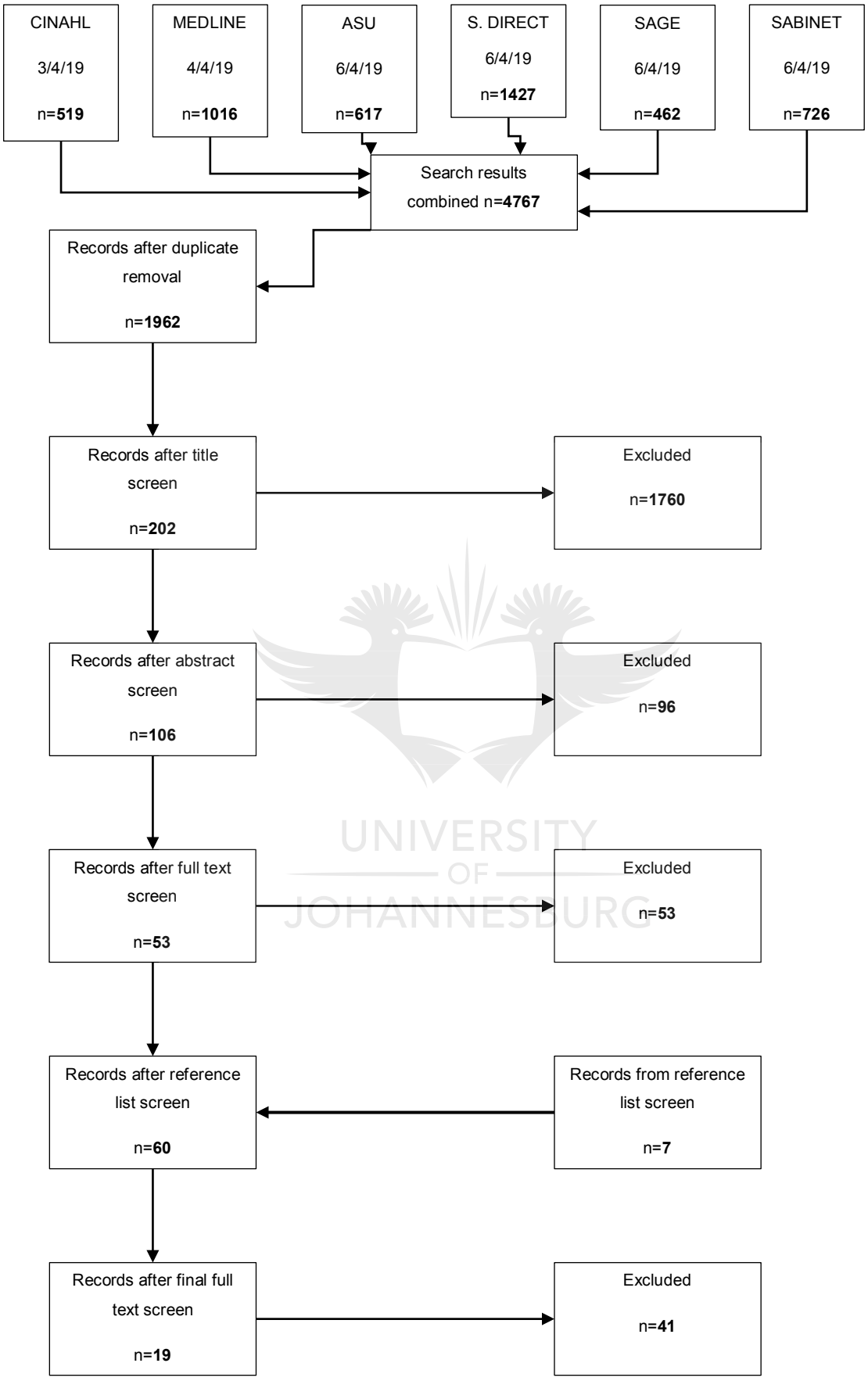


Figure 4.4: PRISMA Flow Diagram - Study Selection

4.5 DESCRIPTION OF INLCUDED STUDIES

The final sample included 19 studies applicable to the research question. All the articles were published in English. The sample was particularly heterogenous in design, setting, and sample. To assimilate this variation, the studies were broadly clustered based on investigated interventions. This classification is illustrated in Tables 4.1 through 4.4 and is described as such.

4.5.1 The Association Between Spinal Immobilisation and Variables

Ten studies observed the association between spinal immobilisation and other variables. Variables considered include pulmonary function, cerebral oxygenation, intracranial pressure, vital signs, cardiac arrest and pressure ulcers. Of these studies, two prospective and one retrospective cohort studies were conducted on trauma patients (Ala, Shams-Vahdati, Taghizadieh, Miri, Kazemi, Hodjati & Jalilzadeh-Binazar, 2016; Tsutsumi, Fukuma, Tsuchiya, Ikenoue, Yamamoto, Shimizu et al., 2018; Ham et al., 2016), six prospective cohort studies were conducted on healthy volunteers with extrapolated data (Akkuş, Çorbacioğlu, Çevik, Akinci & Uzonosmanğlu, 2016; Işik, Demirci, Çorbacioğlu, & Çevik, 2019; Aksel, 2018; Özdoğan, Gökçek, Katirci, Çorbacioğlu, Emektar & Çevik, 2019; Bruijns, Guly & Wallis, 2013; Çorbacioğlu, Akkuş, Çevik, Akinci & Uzunosmanoğlu, 2016), and one study was a systematic review (Ham et al., 2014).

4.5.2 The Efficacy of Equipment in Reducing Spinal Motion

Five studies compared the efficacy of external immobilisers in reducing spinal motion. Devices correlated include various types of cervical collars, head blocks, long backboards, padded patient litters, stretcher mattresses and scoop stretchers. Of these, there were two cohort studies (Weber, Rauscher & Winsett, 2015; Holla, 2012) and two randomised controlled trials (Wampler, Pineda, Polk, Kidd, Leboeuf, Flores, et al. 2016; Swartz, Tucker, Nowak, Roberto, Hollingworth, Decoster et al. 2018) conducted on healthy volunteers, while one study was a systematic review (Holla, Joske, Huisman, Verdonschot, Goosen, Hosman & Hannink, 2016). None of

the studies in this group were conducted on trauma patients. As such, all the evidence is extrapolated.

4.5.3 The Association Between Interventions and Patient Outcomes

Two studies examine the association between interventions directed a suspected spinal injury and patient outcome. The intervention examined in both studies is spinal immobilisation in penetrating trauma, while outcomes include mainly neurological deterioration and mortality. One of these studies was a retrospective cohort of trauma patients (Turnock, Carney, Fleischer, McSwain & Vanderlan, 2016) and the other was a systematic review (Velopulos, Shihab, Lottenberg, Feinman, Salomone & Haut, 2017).

4.5.4 The Implementation of The Canadian C-Spine Rule by Nurses

Finally, the sample included two studies that investigate the clinical safety and specificity of the Canadian C-Spine Rule as a decision tool used by emergency department nurses to remove spinal immobilisation (Fontaine, Forgione, Lusignan, Lanoue & Drouin, 2018; Stiell, Clement, Sheehan, Miller, Armstrong, Bailey, et al. 2018). Both studies were practice improvement projects conducted in two different states in Canada and by different groups of authors. The results may provide valuable insight regarding interventions that can be implemented by nurses in South African emergency departments.

Of the 19 articles, two studies (Turnock et al., 2016; Velopulos et al., 2017) focused exclusively on penetrating trauma, one study (Tsutsumi et al., 2018) focused exclusively on blunt trauma, and the other 16 studies were not specific in this regard.

Table 4.1: Studies examining the association between spinal immobilisation and variables

Title	Author	Year	Design	Study Aim	Intervention	Sample	Results
Cervical collar effect on pulmonary volumes in patients with trauma	Ala et al.	2015	Cohort study	Investigate the effect of CC removal on lung volumes & dyspnoea in patients with GCS 15.	Spinal immobilisation with a CC.	Adult patients admitted to an ED with a chief complaint of trauma and a GCS of 15 and who qualified for CC removal. All patients had no history smoking, lung disease or chest trauma & did not present with multiple trauma. (n=50)	Pulmonary function parameters increased significantly after CC removal. CC application in trauma patients causes a significant decrease in lung capacity and spirometry parameters.
Effects of spinal immobilisation at 20° on respiratory functions	Akkuş et al.	2016	Cohort study	Investigate whether spinal immobilisation at 20° instead of 0° conserves pulmonary function parameters (FEV1, FVC & FEV1/FVC ratio).	Spinal immobilisation with a CC and LBB at 20 ° instead of 0°.	Male and female (non-pregnant) non-smoking healthy volunteers, 25-40 years & with a BMI<30kg/m². (n=56)	Spinal immobilisation at 0° decreased all pulmonary function in all parameters. Spinal immobilisation at 20° decreased pulmonary function in FEV1 and FEV1/FVC ratio, but preserved FVC. Spinal immobilisation at 20° may reduce the decrease in pulmonary function.
Effects of 20-degree spinal immobilisation on respiratory functions in otherwise healthy volunteers with android-type obesity	Işik et al.	2019	Cohort study	Investigate whether spinal immobilisation at 20° instead of 0° conserves pulmonary function parameters in obese volunteers (FEV1, FVC & FEV1/FVC ratio).	Spinal immobilisation with a CC and LBB at 20 ° instead of 0°.	Male and female (non-pregnant) volunteers, 18-45 years, with android-type obesity (BMI 30-40kg/m²) who were otherwise healthy. (n=30)	Spinal immobilisation at 20° and at 0° demonstrated a significant decline in all pulmonary function parameters. Spinal immobilisation at 20° has no conservative effect for pulmonary function in obese adults.
Effects of spinal immobilisation at a 20°angle on cerebral oxygen saturations	Aksel	2017	Cohort study	Investigate whether spinal immobilisation at 20° instead of 0° changes cerebral oxygenation.	Spinal immobilisation with a CC and LBB at 20 ° instead of 0°.	Male and female (non-pregnant) healthy volunteers, 18-39 years with a BMI<30kg/m². (n=33)	Spinal immobilisation at 20° instead of 0° did not alter cerebral oxygen saturation. Spinal immobilisation at 20° was therefore concluded to be

Title	Author	Year	Design	Study Aim	Intervention	Sample	Results
measured by INVOS™							safe with regards to cerebral oxygenation.
The effects of spinal immobilisation at 20° on intracranial pressure	Özdoğan et al.	2018	Cohort study	Investigate whether spinal immobilisation at 20° instead of 0° affects ICP via the USG measurement of optic nerve sheath diameter.	Spinal immobilisation with a CC and LBB at 20 ° instead of 0°.	Male and female (non-pregnant) non-smoking healthy volunteers, 20-40 years and with a BMI<30kg/m². (n=146)	Optic nerve sheath diameter, and thus ICP, increased significantly in spinal immobilisation at 20° and at 0° when compared to baseline measurements. Immobilisation at 20° does not have a protective effect in terms of ICP.
Effect of spinal immobilisation on heart rate, blood pressure and respiratory rate	Bruijns et al.	2012	Cohort study	To establish if pain and discomfort associated with spinal immobilisation and the manoeuvres commonly used in trauma patients affects HR, BP and RR.	Log-roll and spinal immobilisation with a CC, LBB & headblocks.	Adult male and female (non-pregnant) uninjured, healthy volunteers with no history of cardiovascular or respiratory disease. (n=53)	Spinal immobilisation and log-roll resulted in a significant increase in pain & discomfort. However, changes in HR, RR & BP remained clinically irrelevant.
Effect of spinal immobilisation with a long backboard and cervical collar on vital signs	Çorbacioğlu et al.	2016	Cohort study	Investigate the effect of the LBB and CC on neck and /or back pain and changes in vital signs.	Spinal immobilisation with a CC and LBB.	Male & female (non-pregnant) healthy volunteers, 20-30 years, with a BMI<30kg/m² and normal baseline vital signs. (n=45)	Spinal immobilisation resulted in a significant increase in pain and a significant decrease in systolic BP. No significant changes were detected for any other vital signs.
Association between spinal immobilisation and survival at discharge for on-scene blunt traumatic cardiac arrest: A nationwide retrospective cohort study	Tsutsumi et al.	2018	Cohort study	Investigate the association between spinal immobilisation for on-scene traumatic cardiac arrest and survival at discharge.	Spinal immobilisation with a CC and LBB in patients with on-scene cardiac arrest due to blunt trauma.	Cohort from the Japan Trauma Data Bank (2004-2015). Adult patients with on-scene cardiac arrest due to blunt trauma. (n=4313)	1.8% of immobilised patients and 3.7% of non-immobilised patients survived to discharge. 25% of immobilised patients and 41.9% of non-immobilised patients achieved ROSC by admission.
Pressure ulcers, indentation marks and pain from cervical spine	Ham et al.	2016	Cohort study	To describe the occurrence and severity of pressure ulcers, indentation marks	Spinal immobilisation with a CC and headblocks.	All consecutive adult trauma patients admitted to an ED in the Netherlands with	Results demonstrated a high incidence for pressure ulcers and indentation marks. A majority of

Title	Author	Year	Design	Study Aim	Intervention	Sample	Results
immobilisation with extrication collars and headblocks: An observational study				and pain from CC's and headblocks.		standard spinal immobilisation. (n=342)	patients reported pain due to CC and headblocks. This may lead to undesirable cervical movement in order to relieve pressure and pain.
Pressure ulcers from spinal immobilisation in trauma: A systematic review	Ham et al.	2014	Systematic review	Gain insight regarding pressure ulcers related to spinal immobilisation with devices in adult trauma patients.	Spinal immobilisation with external devices.	All quantitative designs examining trauma patients or healthy volunteers under spinal immobilisation and the occurrence, severity, risk factors or interventions for pressure ulcers. (n=13)	An incidence of collar-related pressure ulcers of 6.8% to 38% was demonstrated. Severity varied between stage 1 and 4. Risk factors included pressure, pain and time in device. Prevention involves early replacement & skin assessment.

CC – cervical collar **LBB** – long backboard **GCS** – Glasgow coma scale **ED** – emergency department **FEV1** – forced expiratory volume in 1 second **FVC** – forced vital capacity **ICP** – intracranial pressure **USG** – ultrasonographic **HR** – heart rate **BP** – blood pressure **RR** – respiratory rate **ROSC** – return of spontaneous circulation

Table 4.2: Studies comparing the efficacy of equipment in reducing spinal motion

Title	Author	Year	Design	Study Aim	Intervention	Sample	Results
Comparison of a padded patient litter and a long backboard for spinal immobilisation in air medical transport	Weber et al.	2015	Cohort Study	Compare subject stability and comfort level between a padded litter system with a rigid frame and an LBB.	Spinal immobilisation with a CC, headblocks and LBB or padded litter, at a 45 ° left & right tilt.	Male and female, adult healthy volunteers ≤ 350lb & able to lie flat for up to 45 minutes. (n=42)	No statistical difference in movement was found between devices for the head; however, there was statistically greater movement on the padded litter for the sternum and pelvis.
The long backboard does not reduce lateral motion during transport- a randomised healthy volunteer crossover trial	Wampler et al.	2016	Randomised controlled trial	Evaluate the theoretically reduced movement provided by the LBB as compared with the stretcher mattress alone in healthy volunteers.	Spinal immobilisation with a CC, headblocks and LBB (placed on top of a stretcher mattress) or stretcher mattress alone, in a moving ambulance at 20mph.	Male and female (non-pregnant) healthy volunteers with no pre-existing spinal problems or relevant medications. (n=8)	The LBB allowed greater lateral motion for the head, torso and hip than the stretcher mattress alone. The LBB is likely not the right device for reducing spinal motion in suspected spinal injury.
Value of a rigid collar in	Holla	2012	Cohort study	Analyse the effects on the	Cervical spine	Male and female healthy	The addition of the CC to

Title	Author	Year	Design	Study Aim	Intervention	Sample	Results
addition to head blocks: a proof of principle study				range of motion of the addition of a CC to head blocks strapped to a long backboard.	immobilisation with a CC alone, headblocks alone and a combination of a CC and headblocks.	volunteers, 23 – 47 years with a BMI 18 -28kg/m ² but with different body types. (n=10)	headblocks strapped to an LBB did not result in extra immobilisation of the cervical spine. Opening of the mouth was significantly reduced in patients with a CC.
The ability of external immobilisers to restrict movement of the cervical spine: a systematic review	Holla et al.	2016	Systematic review	Review all articles regarding external immobilisers to quantify and compare their ability to restrict movement of the cervical spine.	Cervical spinal immobilisation with an external device.	Studies reporting a reduction in cervical motion compared with normal motion in healthy adults or human cadavers using a reliable and reproducible measuring method. (n=13)	Soft collars: poor ability to reduce CROM. Cervico-high thoracic devices: moderate ability to reduce flexion/extension, but poor ability to reduce lateral bending and rotation. Cervico-low thoracic devices: moderate ability to reduce flexion/extension, poor ability to reduce lateral bending. Cranio-thoracic devices: substantial restriction in all planes.
Pre-hospital cervical spine motion: Immobilisation versus spine motion restriction	Swartz et al.	2018	Randomised controlled trial	Compare the difference in CROM between traditional spinal immobilisation and spinal motion restriction, during transport of a simulated patient.	Spinal immobilisation with a CC, headblocks and LBB (TSI) or a CC and ambulance cot only (SMR) in a simulated pre-hospital scenario.	Male, college-aged healthy volunteers with no history of cervical spine or respiratory pathology and who were able to lie supine and motionless for up to 60 minutes. (n=20)	There was greater transverse plane cumulative integrated motion during TSI compared to SMR. Pain was reported by 40% of participants in TSI and by 25% of participants in SMR.

LBB – long backboard **CC** – cervical collar **CROM** – cervical spine range of motion **SMR** – spinal motion restriction **TSI** – traditional spinal immobilisation

Table 4.3: Studies examining the association between interventions directed at suspected spinal injury and patient outcomes

Title	Author	Year	Design	Study Aim	Intervention	Sample	Results

Cervical spine immobilisation in penetrating cervical trauma is associated with an increased risk of indirect central neurological injury	Turnock et al.	2016	Cohort study	Examine the relationship between penetrating cervical trauma and the development of central neurologic injury with preventative cervical spinal immobilisation	Cervical spine immobilisation in penetrating cervical trauma.	Patient database of patients with penetrating cervical trauma, constructed from the Trauma Registries of two Level 1 Trauma Centres in the USA. (n=231)	Cervical spine immobilisation was a significant risk factor for central neurologic injury. Spinal immobilisation demonstrated no benefit, but rather an absolute risk increase for central neurologic injury of 18.69%
Pre-hospital spine immobilisation/spinal motion restriction in penetrating trauma: A practice management guideline from the Eastern Association for the Surgery of Trauma (EAST)	Velopulos et al.	2017	Systematic review	Review published evidence on PHSI/SMR in patients with penetrating trauma to structure a guideline for practice. (Does the practice decrease mortality or neurological deficit)	Spinal immobilisation in patients with penetrating trauma.	Randomised controlled trials, retrospective and prospective observational studies and case-control studies examining spine immobilisation versus no spine immobilisation in adult patients with penetrating trauma. (n=155089)	No study demonstrated any benefit of spine immobilisation in penetrating trauma. Spine immobilisation is associated with increased mortality and has not been shown to have any effect on preventing neurological deficit

PHSI – pre-hospital spinal immobilisation **SMR** – spinal motion restriction

Table 4.4: Studies examining the implementation of the Canadian C-Spine Rule by emergency department nurses

Title	Author	Year	Design	Study aim	Intervention	Sample	Results
Cervical spine collar removal by emergency room nurses: A quality improvement project	Fontaine et al.	2018	Cohort study	Train ED charge nurses to use the CCR, monitor its use and compare the assessments of charge nurses with those of emergency physicians.	Removal of spinal immobilisation in alert, orientated, low risk, adult trauma by ED charge nurses using the CCR as a decision tool.	Charge nurses in a Canadian ED on day and night shift. (n=9) Alert, orientated, low risk adult trauma patients who arrived at the ED with a CC in place. (n=114)	Charge nurses removed CC's for 47% of patients. An agreement rate of 100% was achieved between the charge nurses and emergency physicians regarding the decision to remove the CC.

Title	Author	Year	Design	Study aim	Intervention	Sample	Results
A multicenter programme to implement the Canadian C-Spine Rule by emergency department triage nurses	Stiell et al.	2018	Cohort study	Evaluate the clinical effect and safety of real-time CCR implementation by ED triage nurses to remove cervical spine immobilisation.	Removal or application of spinal immobilisation in alert, orientated, low risk, adult trauma by ED triage nurses using the CCR as a decision tool.	Triage nurses from 8 ED's at teaching hospitals in Ontario, Canada. (n=180) Alert, orientated, stable adult patients admitted to ED with suspected spinal injury due to blunt trauma and without acute paralysis or known vertebral disease. (n=1408)	Spinal immobilisation removal occurred in 41.1% of cases, of which there were 0 missed cervical injuries. Time to discharge was reduced by 26% for this group.

CCR – Canadian C-Spine Rule **ED** – emergency department **CC** – cervical collar

4.6 QUALITY APPRAISAL

4.6.1 Quality Appraisal Using CASP

Following study selection, the quality of each included article was assessed using the
CASP (*CASP - Critical Appraisal Skills Programme*, 2018:CASP Checklists). CASP provides a set of design-specific checklists as tools for the critical appraisal of research.

Relevant checklists were used for the assessment of included cohort studies, randomised controlled trials and systematic reviews. Each checklist is divided into three main sections that evaluate the validity of results, the nature of results and the generalisability of results. Each section contains a series of applicable questions that require an initial 'yes', 'no' or 'can't tell' response. In addition, a space is provided on the checklist to elaborate on the rationale and justification for the brief response.

Answering each question entails critical thinking and careful assessment of the respective methodological element under scrutiny. Some specific elements evaluated include the focus of study, recruitment and management of subjects, risk of bias, as well as how the results fit with other research and with a real-life scenario.

4.6.2 Dual Independent Quality Appraisal

A CASP checklist was completed, with reasons for answers, for each included study. This process was completed by the researcher. A checklist was also completed for each included study by the independent reviewer. Following separate appraisals, a consensus conversation served to confer answers and agreement was reached for each relevant article.

The CASP results are tabulated next for transparent reporting and objective comparison. Additionally, an example of a completed CASP for each design is provided as Addendum G, H and I.

Table 4.5: CASP Cohort Study Checklist

CASP Appraisal Questions	Ala et al.	Işik et al.	Aksel	Bruijns et al.	Çorbacioğlu et al.	Tsutsumi et al.	Ham et al.	Weber et al.	Holla	Turnock et al.	Fontaine et al.	Stiell et al.	Akkuş et al.	Özdoğan et al.
Did the study address a clearly focused issue?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was the cohort recruited in an acceptable way?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was the exposure accurately measured to minimise bias?	CT	Y	CT	CT	CT	Y	Y	Y	Y	CT	Y	Y	CT	CT
Was the outcome accurately measured to minimise bias?	Y	Y	Y	Y	CT	Y	Y	Y	Y	CT	Y	Y	CT	Y
Have the authors identified & accounted for confounding factors?	N	N	N	N	N	Y	Y	N	N	N	CT	N	N	N
Was the follow up of subjects complete & long enough?	CT	Y	Y	Y	Y	Y	Y	CT	CT	Y	Y	Y	Y	Y
Do you believe the results?	CT	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Can the results be applied to the local population?	Y	N	Y	CT	CT	Y	Y	Y	Y	Y	Y	Y	CT	Y
Do the results of the study fit with other available evidence?	Y	Y	CT	Y	Y	Y	Y	N	CT	Y	Y	Y	Y	Y

Y – yes **N** – no **CT** – can't tell

Table 4.6: CASP Systematic review Checklist

CASP Appraisal Questions	Ham et al.	Holla	Velopulos et al.
Did the study address a clearly focused question?	Y	Y	Y
Did the authors look for the right type of papers?	Y	N	Y
Do you think all the important, relevant studies were included?	Y	N	Y
Did the review authors do enough to assess the quality of the included studies?	Y	Y	Y
If the results of the review have been combined, was it reasonable to do so?	Y	Y	Y
Can the results be applied to the local population?	Y	CT	Y
Were all the important outcomes considered?	Y	Y	Y
Are the benefits worth the harms and costs?	N	N	N

Y – yes **N** – no **CT** – can't tell

Table 4.7: CASP Randomised Controlled Trial Checklist

CASP Appraisal Questions	Wampler et al.	Swartz et al.
Did the trial results address a clearly focused issue?	Y	Y
Was the assignment of patients to treatments randomised?	Y	CT
Were all of the patients who entered the trial properly accounted for at its conclusion?	Y	Y
Were patients, health workers and study personnel 'blind' to the treatment?	N	N
Were the groups similar at the start of the trial?	CT	Y
Aside from the experimental intervention, were the groups treated equally?	Y	Y
Can the results be applied to the local population, or in your context?	Y	Y
Were all the clinically important outcomes considered?	Y	Y
Are the benefits worth the harms and costs?	N	N

Y – yes **N** – no **CT** – can't tell

4.7 DATA EXTRACTION

4.7.1 Narrative Data Extraction

Following quality appraisal, a process of data extraction was employed. Relevant information was identified and recorded to deconstruct included studies for analysis and synthesis at a later stage. A data extraction form, developed, tested and refined during the pilot study, was used for this purpose. Created on Microsoft Word, this master copy served as a blueprint to narratively abstract and categorise meaningful information from each article. A separate Word document was completed for each included study and information collected included design and objectives, interventions and outcomes, methods of research, results and implications for practice. An example of the data extraction form is illustrated in Addendum J.

4.7.2 Statistical Data Extraction

As planned in the pilot study, an additional data form was created for the extraction of statistical data. Four identical Microsoft Excel sheets were constructed, one for each cluster of studies described in Tables 4.1 through 4.4 of this chapter. Statistical results for primary outcomes in each study were extracted exactly as reported in each article. Where no statistical analysis was done, numerical data were extracted

as reported; for example, total values and percentages. The results for the systematic reviews by Ham et al. (2014) were entirely narrative. The review reported statistical results for individual primary studies included but reported no synthesised numerical data. Data were recorded as 'not reported' on the Excel sheet for this study. The Excel data sheet is too large to attach as an Addendum. An example of statistical results extracted is tabulated and attached as Addendum K.

4.7.3 Further Details Regarding Data Extraction

In addition to the two data extraction forms, distinct characteristics relevant to the research question were tabulated for comparison across included studies. The differentiating features tabulated were author, spine region of interest, type of trauma investigated (blunt or penetrating), type of subjects (healthy volunteers or trauma patients), sample size, intervention, and results based on primary and secondary outcomes.

Where studies described samples and populations as 'adults' it was assumed that all the individuals within the group were above 12 years of age. Similarly, when the term 'suspected spinal injury' was not explicitly defined, the assumption was made that the authors meant to describe a potential, but undiagnosed, spinal injury due to a mechanism inducing a high degree of suspicion for such an injury. The term 'spinal immobilisation' was frequently used across all included studies and was generally well defined or at least alluded to in a way that made the meaning clear. The definition differed slightly depending on the objectives of the study. Details regarding the intended meaning of the term was reported under 'intervention' in the narrative data extraction form as well as in the tabulated summary.

Accepted guidelines often recommend that data extraction be completed independently by at least two reviewers (Munn et al., 2014:49). As for the search and study selection, the process was conducted by the primary researcher for academic evaluation. The completed extracted data forms were then examined by the supervisor to verify correctness and completeness.

4.8 DATA SYNTHESIS

4.8.1 Meta-Analysis

A statistician from the University of Johannesburg was consulted to determine if a meta-analysis of quantitative results would be possible. A discussion was held between the researcher, the supervisor and the statistician to clarify the aims and objectives of the study. The statistician was provided with the data extracted from the included articles. Following the appropriate assessments, significant heterogeneity was found across all studies. Nonetheless, a meta-analysis for pain was attempted. This outcome was chosen because it was the most frequent. Despite the attempt, a meta-analysis was considered impossible by the statistician, whose reasons are briefly summarised next.

4.8.1.1 Meta-Analysis for Pain

A thorough assessment for risk of bias (Ahn & Kang, 2018:105-105) was not possible because the research design, except for one design, is a single group design. This is a weak design as there is no comparison group. In the studies, the researchers used the same group at time 0 as the 'control' group. In the one study with random allocation of two groups, the sample sizes are problematic (n=5 and n=3).

Studies do not use the same measure of pain; three use a visual analogue scale (VAS) while two use a 10-point pain rating. Standardising these measures would be problematic as the unit of measurement is different across studies. Of the three using VAS, two report means and standard deviations (but one of these studies has problem with sample size), the other reports median and interquartile range. For the 10-point pain scale, one study reports percentage with pain and the second argues pain rating is not clinically useful. Periods of time when measurements are taken also differ across studies. Ahn and Kang (2018:105) advise that combining quantitative data is inappropriate if there are significant differences in measurement techniques or evaluation time points.

In summary, a meta-analysis of the outcome 'pain' was inappropriate due to weak quality and differentials in measurement of the outcome variable.

4.8.2 Narrative Synthesis

A narrative synthesis of results was conducted based on the guidance provided by the ESRC Methods Programme (Popay et al., 2006:11-23). The evidence-based framework outlines four elements that are dependent on each other for fulfilment. The guideline suggests that the practical steps within each element are adapted to the unique characteristics of the review and completed in an iterative manner. For logical reading, the elements of synthesis are presented here as sequential steps, although in reality application of the elements took on a back and forth flow of execution. The steps within each element are presented in the order in which they were completed in the results section of the next chapter.

4.8.2.1 Element 1 - Theory Development

An awareness of concepts, opinions and assertions regarding suspected spinal injury and the management thereof was a benefit gained from the intricate probe required in undertaking this systematic review. The familiarity with the subject afforded an understanding that enabled theory development to clarify and inform the analysis of results. A theory was developed based on common principles described in the background and introduction of included articles. Presented as a concept map, the theory aims to describe the flow and development of the core concepts underpinning the intervention. Furthermore, this initial step provided a broad summary of emerging ideas that laid the foundation for subsequent processes in the narrative synthesis.

4.8.2.2 Element 2 – Developing A Preliminary Synthesis

A preliminary synthesis provides a means to organise and summarise included articles. This initial integration is essential for the identification of patterns across studies and is intended to highlight similarities and differences across results. From the tools suggested by the guideline, a textual description of studies and a thematic analysis was chosen as most appropriate.

A textual description of each article provided a basis for summarising and organising the large volume of extracted data. An individual report of each included study describes the design, objective, population, concept, context, results and conclusion in a systematic manner. Studies are discussed in lesser or greater detail based on the information available in the published report. Completing this step was of value in highlighting elements essential for synthesis, particularly how the intervention was defined by authors as well as the results of each outcome.

The identification of patterns in the results of included articles followed textual descriptions and constitutes element three. The emerging patterns formed the foundation of a thematic analysis. The research question for the review seeks to identify the most beneficial outcomes and which interventions produced them. In an endeavour to answer the question, the outcomes were established as the themes for analysis. The results from similar outcomes across multiple studies were synthesised by comparison and contrast of the direction of effect. The body of information produced by data extraction was large, as well as variable in terms of design and methodology. These complexities made further synthesis impossible and an inductive thematic analysis was therefore considered most fitting.

4.8.2.3 Element 3 – Exploring Relationships Within and Between Studies

The guideline by Popay et al. (2006:11-23) describe a reflection of relationships between findings as an essential element in a narrative synthesis. A broad differentiation is made between two types of relationships, namely those between characteristics and those between findings of included studies. Such relationships were unveiled through theory development and textually describing studies. Of the tools suggested by the guideline, idea webbing and concept mapping were chosen to further explore and illustrate the relationships and emerging patterns.

The relationships between characteristics of studies was explored and mapped within the same framework used to structure the research question. Studies were grouped based on similar populations, contexts and concepts. The similarities were then tallied and are presented as percentages to illustrate variation in how the

intervention was defined as well as the fields within which research was conducted and the samples used. The population, concept, context framework was upheld to remain consistent and systematic in using results to answer to the research question.

Regarding relationships between findings of the study, a pattern of common outcomes overlapped across multiple included studies emerged in the process of textually describing the research. The included articles vary in design, methods, population, context and even definitions of the concept. Despite this, the process of synthesis revealed agreement in the outcomes sought which naturally developed into the foundation for a thematic synthesis. The relationships between characteristics and between findings of included studies were mapped and are displayed as diagrams in the results section in Chapter Five.

4.8.2.4 Element 4 – Assessing the Robustness of the Synthesis

An assessment of the quality of the included studies and the quality of the synthesis is described as a complex but valuable element in the process. The two components of robustness are interrelated and have a direct impact on the weight of evidence produced by the synthesis. A poor quality of the included research may compromise the reliability and validity of conclusions drawn from the synthesis. For this review, all relevant studies were included regardless of methodological quality. Included in the thematic synthesis, unfavourable responses to the CASP checklists were cited and discussed. This step formed the application of element four and constituted a measure to mitigate the introduction of bias through the inclusion of poor-quality studies. In addition, the mention of quality as part of the synthesis aims to produce transparent reporting an facilitate objective judgement by the consumer.

An assessment of the robustness of the synthesis itself relates to the systematic nature and attentiveness in the application of element one to three. A reflection of the synthesis process is suggested by the guideline as a tool for assessing robustness. The description of the process presented here serves this purpose and further limitations of the synthesis, and study as a whole, are subsequently discussed.

4.9 CONCLUSION

This systematic review was conducted in accordance with accepted standards and guidelines described in Chapter Three. Transparent reporting of methods was guided by the PRISMA statement (Moher et al., 2009:266) where appropriate, as well as the text 'Doing a Systematic Review – A Student's Guide' (Boland et al., 2014).

With the research question and eligibility criteria previously explicated, this chapter described the practical steps taken in conducting the review. A search strategy built around keywords from the research question yielded 1962 potentially relevant titles. Systematic screening of titles, abstracts and full texts eliminated irrelevant records and produced a final sample of 19 studies for inclusion. A brief description of these studies was followed by quality appraisal based on the checklists provided by CASP.

Narrative and statistical data extraction was completed using standardised forms already tested in the pilot study. Meta-analysis was deemed inappropriate following an assessment of heterogeneity and consultation with a statistician. Extracted data was therefore synthesised narratively in accordance with the guideline provided by the ESRC Methods Programme.

Much of the review was conducted independently by the primary researcher, as the review is for the fulfilment of requirements for the award of academic recognition. In light of this, consultation with an external reviewer aimed to minimise the introduction of bias in the screening phase as well as quality appraisal. While this chapter focused explicitly on the reporting of methods, results of the review are presented in the next chapter.

CHAPTER FIVE
RESULTS

5.1 INTRODUCTION

Synthesised data from individual studies are the results of a systematic review (Munn et al., 2014:49). This chapter describes the synthesis, and therefore, the results of the review.

A meta-analysis was considered inappropriate for the outcome pain, and impossible for all other outcomes. Data extracted from included studies were therefore synthesised narratively. This method of data analysis is particularly vulnerable to bias as it often takes on a subjective nature. The CRD therefore strongly recommends that a narrative synthesis be highly systematic in nature and be guided by accepted and approved standards (Centre for Reviews and Dissemination, 2009:48). The systematic process provided by the ESCR Methods Programme (Popay et al., 2006:23) was followed to narratively synthesise data.

The results from 19 included studies exploring interventions directed at the care of suspected spinal injury in trauma patients have been synthesised. In accordance with the guideline, words have been used to systematically portray the evidence.

A theory of change illustrates concepts related to the intervention, its relevance and development in emergency nursing care. A textual description of each included article identifies and summarises key aspects within each study. Relationships between characteristics and findings of studies, illustrated using idea webbing, reveals patterns in similar outcomes overlapped across various studies. These patterns of common outcomes then form the framework for a thematic analysis that highlights the direction of effect detected by each article. Aspects of quality appraisal

are discussed in conjunction with the thematic analysis to mitigate the lack of weighting in a narrative synthesis as well as to facilitate transparent reporting.

5.2 THEORY DEVELOPMENT

Theory development serves to clarify the concepts and constructs within the area of focus to aid interpretation of results (Popay et al., 2006:12). The theory presented here was constructed based on themes that run consistently through relevant articles. The paradigm illustrates how suspected spinal injury due to trauma is perceived and approached among emergency healthcare personnel. Furthermore, a paucity of high-level evidence to support these interventions was revealed, as well as the resulting investigations that have dominated academia in recent years. A concept map illustrating the theory is presented in Figure 5.1.

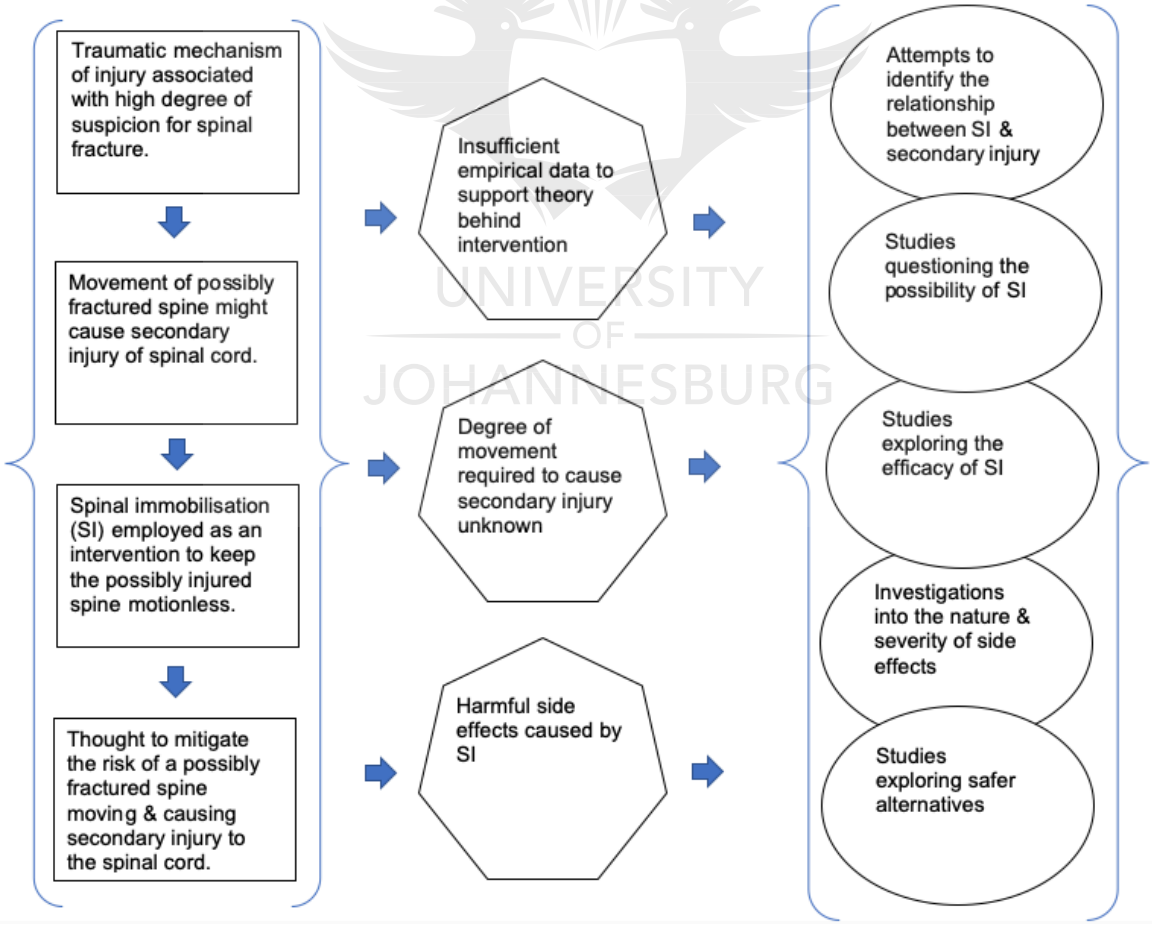


Figure 5.1: Theory of Change

Key: **SI** = spinal immobilisation

5.3 TEXTUAL DESCRIPTION OF INCLUDED STUDIES

A prospective cohort study by Akkuş et al. (2016:1959-1960) compared pulmonary function in healthy volunteers immobilised at 0 degrees to those immobilised at 20 degrees. Hypothesising that spinal immobilisation in this modified position would reduce the compromised pulmonary function that presents at 0 degrees, the authors measured variables of spirometry in both positions. In a controlled environment, 56 healthy volunteers were randomly divided into two groups (n=30 and n=26). Forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC) and the ratio between the two (FEV1/FVC) were measured in a seated position to obtain baseline values. Each subject was then immobilised with a cervical collar and a long backboard for 30 minutes. During this period, one group was positioned supine at 0 degrees and the other supine at 20 degrees. The spirometry measurements were repeated upon commencement of immobilisation, after 5 minutes and after 30 minutes. Values were then compared between the groups to determine the effect of the modified position on pulmonary function.

Results revealed a statistically significant decrease in all variables when volunteers were immobilised at 0 degrees. When immobilised at 20 degrees, the FEV1 and FEV1/FVC ratio was significantly decreased, but the FVC remained consistent with baseline values (p=.45). Based on these findings, the authors suggest spinal immobilisation at 20 degrees to protect a suspected spinal injury as a safer alternative to immobilisation at 0 degrees, rationalising that the modified position may preserve pulmonary function in injured patients with suspected spinal injury.

In a similar study, Işik et al. (2019:1-5) examined the effect that spinal immobilisation at 0 degrees and at 20 degrees has on pulmonary function. However, the cohort consisted of volunteers with a body mass index (BMI) of 30-40 kg/m² and a waist-hip ratio above 0.90 in males and 0.85 in females. The otherwise healthy volunteers were therefore defined as obese as per WHO criteria. The authors sought to establish if the modified position preserves pulmonary function in this population as is the case in non-obese volunteers. In a sample of 30 subjects, FEV1, FVC and FEV1/FVC ratios were measured in a seated position, immobilised with a cervical

collar and long backboard at 0 degrees, and again at 20 degrees in the same group on the following day. Spirometry measures were obtained at the start of immobilisation and after 30 minutes, and then compared to baseline values. The simulated immobilisation was conducted in a controlled environment in the emergency department of a teaching hospital.
Results demonstrated a statistically significant decline in all measures of pulmonary function in both positions of immobilisation (p= <0.001 in all values). Hence, the protective effects that were found in the first study, where volunteers had a normal BMI, was not present in obese volunteers. The authors conclude that obesity contributes adversely to the compromised respiratory function present in spinal immobilisation, even when patients are elevated to a 20-degree angle.

Aksel (2018:84-87) conducted a prospective cohort study to compare cerebral oxygen saturation in healthy volunteers immobilised at 0-degree and 20-degree angles. Thirty-three volunteers were immobilised with a neck collar and long backboard at a 0-degree angle in a simulation setting in an emergency department at a teaching hospital. Cerebral oxygen saturation was measured with an INVOS™ near-infrared oximetry at timed intervals. The same group of volunteers were then immobilised in similar fashion on the following day, but at a 20-degree angle, and the measurements were repeated at time intervals identical to the first procedure. Cerebral oxygenation decreased slightly when the backboard was elevated to a 20-degree angle (p=.768) compared to the 0-degree position (p=.220). Although a difference was detected, the authors conclude that it was not clinically significant and therefore suggest that spinal immobilisation at 20 degrees could be used as a safer alternative to the 0-degree position as the modification is safe in terms of cerebral oxygenation.

Özdoğan et al. (2019:1327-1330) also examined spinal immobilisation at 0-degree and 20-degree angles. The prospective cohort study aimed to determine if spinal immobilisation at a 20-degree angle had an effect on intracranial pressure, which is known to increase in spinal immobilisation at 0 degrees. Increased intracranial pressure was judged based on the ultrasonographic measurements of bilateral optic nerve sheath diameters. One hundred and forty healthy volunteers recruited from an emergency department at a teaching hospital were randomly divided into two

groups. All volunteers were immobilised with a cervical collar and long backboard, one group at 0 degrees and the other at 20 degrees. Bilateral optic nerve sheath diameter was measured at identical time intervals for both groups. The results of the investigation demonstrated a significant increase in left and right optic nerve sheath diameter in the group immobilised at 0 degrees (p= <.001 and <.001 respectively) as well as in the group immobilised at 20 degrees (p= <.001 and .001 respectively). The authors infer that spinal immobilisation in both positions leads to increased intracranial pressure, and further deduce that the modified position would have no benefit in terms of this variable.

A retrospective cohort study by Ala et al. (2016:657-660) considered the effect of cervical collar removal on respiratory function. All adult trauma patients admitted to an emergency department in Iran with a cervical collar for suspected spinal injury were screened for inclusion. Alert patients who qualified for collar removal following a clinical investigation were included, while those with chest trauma, multiple trauma or a history of smoking or lung disease were excluded. Spirometry parameters were tested in 50 eligible patients before and after collar removal and included FEV1, forced expiratory volume in 6 seconds (FEV6), FEV1/FEV6 ratio, peak expiratory flow (PEF), FVC. A comparison was made between the two data sets to establish the effect that cervical collars have on respiration.

The investigation detected a significant increase in all the parameters after collar removal when compared to the measurements taken prior to collar removal. The calculated p values were FEV1 <.001, FEV6 .008, FEV1/FEV6 ratio <.001, PEF <.001 and FVC .004. The findings imply that spinal immobilisation with a cervical collar leads to decreased lung capacity and increase the risk of hypoxia. The authors therefore advise that collars be removed from trauma patients as soon as possible.

In a prospective cohort study, Bruijns et al. (2013:210-214) investigated how pain and discomfort associated with spinal immobilisation and the log-roll manoeuvre affects vital signs. Fifty-three healthy volunteers were subjected to a simulated scenario that trauma patients with suspected spinal injury are commonly subjected to. Each subject was immobilised with a cervical collar, head blocks and long backboard. Following a 10-minute rest period, the subject was log-rolled and the

long backboard removed. Another 10-minute rest period in the cervical collar and head blocks followed before removal of all spinal immobilisation. Pain, discomfort, heart rate, blood pressure and respiratory rate were measured prior to immobilisation, 10 minutes after full immobilisation, 10 minutes after log-roll and backboard removal, and 5 minutes after the removal of the collar and blocks.

Statistical testing revealed a difference in vital signs between interval measures with p values <.05 for systolic blood pressure, .01 for heart rate and .01 for respiratory rate. However, when these values were compared to set outcome measures, they were not clinically significant. A significant increase in pain (p=.003) and discomfort (p<.001) was detected when measures during spinal immobilisation were compared with those at rest. The authors conclude that there is no relationship between spinal immobilisation and abnormal vital signs, although they advise a cognisance of the pain and discomfort that the intervention may cause.

A prospective cohort study by Çorbacioğlu et al. (2016:65-68) simulated spinal immobilisation in healthy volunteers to establish the effect that the intervention has on pain scores and vital signs. Forty-five volunteers were immobilised with a cervical collar and long backboard for 30 minutes. Heart rate, respiratory rate, blood pressure and oxygen saturation were measured at the start of the procedure, after five minutes and again after 30 minutes. In addition, pain was measured at the same time intervals using a VAS.

A significant increase in pain scores (p<.001) and a significant decrease in systolic blood pressure was detected (p=.01). No significant changes were detected in diastolic blood pressure, heart rate, respiratory rate and oxygen saturation. The authors caution healthcare providers to be aware that spinal immobilisation increases pain significantly. Furthermore, concluding statements cite contradicting results from the study by Bruijns et al. (2013:212) as a rationale for further investigations on larger cohorts.

Tsutsumi et al. (2018:124-129) retrospectively reviewed a cohort, from the Japan Trauma Bank (2004-2015), of blunt trauma victims who presented with on-scene cardiac arrest. Within the context of pre-hospital care, the research investigated the

relationship between spinal immobilisation and survival at discharge, as well as return of spontaneous circulation (ROSC) by admission. The sample included 4 313 trauma patients who were pulseless on scene and received chest compressions by emergency services. Patients presenting with penetrating trauma, below 16 years of age, or treated by a physician on scene, were excluded. Furthermore, patients with an Abbreviated Injury Scale (AIS) of 6, and cases with a time delay of 30 minutes or more from call to arrival were also excluded as such patients would have a low chance of survival. The authors compared the outcomes in patients who were immobilised on scene with a cervical collar and long backboard to those who were not immobilised at all. Adjustments were made for relevant confounding variables which included age, gender, pre-hospital interventions, injury severity score (ISS), AIS, and time from call to arrival of emergency services.

The immobilised group represented 76.7% of the sample and had a higher median ISS as well as a greater unadjusted proportion of chest injuries compared to the non-immobilised group that represented 23.3% of the sample. One-point-eight percent of immobilised patients and 3.7% of non-immobilised patients survived to discharge, while 25.0% of immobilised patients and 41.9% of non-immobilised patients attained ROSC by admission. When adjusted for confounders, immobilised patients had a lower chance of survival (odds ratio 0.64) and possibility ROSC (odds ratio 0.48) compared to non-immobilised patients. The authors therefore caution against pre-hospital spinal immobilisation for blunt trauma patients who present pulseless.

A prospective cohort study by Ham et al. (2016:1924-1931) characterises pressure ulcers, indentation marks and pain associated with spinal immobilisation. Consecutive trauma patients admitted to an emergency department in the Netherlands, over a 12-month period, with suspected spinal injury due to trauma, were included. Patients presenting with burn wounds >10% or existing compromised skin integrity were excluded, as well as those not admitted directly from the scene of the incident. Included patients arrived at the emergency department immobilised with a cervical collar, head blocks and a long backboard. Following a primary assessment, the long backboard was removed, and patients remained in a supine position in a cervical collar and head blocks until a spinal injury was diagnosed or excluded. The incidence and severity of pressure ulcers and indentation marks, as

well as a pain score, was measured by an emergency nurse immediately prior to and immediately after removal or replacement of spinal immobilisation. Data were collected on confounding variables such as age, gender, BMI, Glasgow Coma Scale, ISS, mean arterial pressure and time immobilised.

Three hundred and forty-two patients were included in the cohort and spent a mean time of 117 minutes immobilised. A pressure ulcer incidence of 78.4% was detected and indentation marks were observed in 64.6% of patients. The chest, back and shoulders were most susceptible to pressure ulcers, and all indentation marks followed the pattern of the cervical collar. Sixty-three-point-two percent of patients reported pain, of which 16.7% was mild, 24.6% moderate and 38.5% severe. Pain was most often experienced on the occiput. In light of these results, the authors suggest that alternative interventions be explored. The likelihood of inadvertent movement due to pain as well as the high incidence of pressure ulcers and indentation marks are highlighted as motivating factors for a revision in clinical practice.

Similarly, a systematic review by the same authors (Ham et al., 2014:113-1141) analysed literature relevant to the incidence and severity of pressure ulcers associated with spinal immobilisation. In addition, risk factors and preventative measures composed outcomes of interest. Database and hand searching literature published between 1979 and 2011 produced 13 quantitative studies with a collective sample size of 1 180 healthy volunteers and trauma patients subjected to spinal immobilisation. Spinal immobilisation was defined as any external immobiliser applied temporarily to protect a suspected spinal injury until such an injury is confirmed or excluded.

Only pressure ulcers related to cervical collars were described, with an incidence of 6.85 to 38%. Pressure ulcers in all stages of development were described as well as the anatomical regions in which they most commonly occurred. Risk factors were described in six out of 13 studies, while three studies suggested preventative interventions. An increased tissue interface pressure, increased pain and increased discomfort from the long backboard with hard and soft surfaces was also described in included articles. In conclusion, the authors stress that nurses should be

conscious of the risk of pressure ulcers in immobilised patients and should, as far as possible, implement reasonable preventative measures.

Weber, Rauscher and Winsett (2015:213-217) conducted a prospective cohort study comparing the degree of immobilisation achieved by a long backboard and padded litter. With a cohort of 42 healthy volunteers, the study explores the concept within the context of air medical transport. Left and right lateral tilt that a supine patient in a helicopter may be subjected to was imitated on a tilt table designed for this purpose. Each subject was immobilised with a cervical collar, head blocks and a long backboard and then secured onto the tilt table. The table was then tilted left and right at 45-degree angles, and the measure of shift in the head, torso and hips was recorded in inches. The same procedure was then repeated on the same subjects, but the long backboard was replaced with a padded patient litter. Comfort was also evaluated and based on a 10-point verbal rating pain score.

When values for each device were compared, no significant difference was detected in movement of the head (p=.36). The measures did, however, reveal significantly greater movement in the sternum (p=.000) and pelvis (p=.000) when patients were immobilised on the padded litter. An increase in discomfort was present for both devices, but they were small and not considered clinically relevant. Based on the findings, the authors confirm that a long backboard provides greater stabilisation when tilting is inevitable. However, they underline that the primary function of the long backboard is extrication and advise that the device only be used to prevent secondary spinal injury when the event is deemed life-threatening.

A randomised controlled trial by Wampler, et al. (2016:717-721) also compared the degree of immobilisation achieved by the long backboard and a softer surface, a stretcher mattress in this case. The trial was conducted on nine healthy volunteers who were randomly divided into two groups. Both groups were immobilised with a cervical collar and head blocks, but one group was further immobilised on a long backboard while the other on a stretcher mattress. With pre-hospital care in mind, each subject was driven a prescribed course in an ambulance at 20 miles per hour. Lateral motion was measured and recorded in the head, torso and pelvis by means of a laser pointing at graduated discs placed in the relevant anatomical positions.

Data on pain and anxiety were also collected using a VAS. The ambulance driver was blinded to the method of immobilisation, and the subjects were blinded to the hypothesis.

Data from one subject were omitted from analysis due to difficulties in data collection. Results from the remaining eight subjects revealed greater aggregated lateral motion (p=.0001) in subjects immobilised on the long backboard compared to the stretcher mattress. This means increased movement was evident in the head (0.5cm), torso (1.7cm), and pelvis (0.8cm). No significant difference in pain and anxiety was detected when these outcomes were compared between the long backboard and stretcher mattress. These results suggest that the long backboard does not provide more efficient immobilisation than the stretcher mattress. As the authors highlight, the sample size is small and cannot be used to change practice, however the implied consequence seems worthy of further scrutiny.

In keeping with the concept of comparing lateral motion between various devices, Swartz, et al. (2018:630-636) focused specifically on the cervical spine in a randomised controlled trial. The study examines the difference in cervical spine range of motion between traditional spinal immobilisation and a variation of the intervention known as 'spinal motion restriction'. Twenty healthy volunteers were all subjected to both methods in a counterbalanced order. Traditional spinal immobilisation was simulated by securing subjects to a long backboard in supine position with a cervical collar and head blocks in place. Spinal motion restriction was simulated by placing patients onto a stretcher mattress with only a cervical collar in place. In both methods, subjects were taken through a simulated scenario that an injured patient would be likely to undergo, including initiation of immobilisation/restriction, loading into an ambulance, driving a prescribed course in the ambulance, unloading from the ambulance and transfer to an emergency department stretcher. For spinal immobilisation the last step was achieved by log-roll whereas a sheet transfer method was used for spinal motion restriction. Range of motion in the cervical spine was measured during each scenario using MyoMotion measurement sensors attached to the forehead and sternum of subjects. Vital signs and pain were also measured at baseline and at regular intervals during each scenario.

No significant difference was detected for lateral bending and flexion-extension when comparing the two scenarios (p reported as >.05 for all). There was, however, greater aggregated axial rotation (p=.049) when subjects were immobilised with head blocks and a long backboard. Such motion was explicitly identified during loading and unloading subjects from the ambulance. Pain was reported by 40% of subjects during traditional spinal immobilisation and by 25% of subjects for spinal motion restriction. Blood pressure was also higher for traditional spinal immobilisation. Considering reported adverse effects associated with traditional spinal immobilisation, motion restriction with only a collar and stretcher mattress is suggested as an alternative as it seems to provide similar, if not superior, control of the cervical spine.

A cohort study by Holla (2012:104-107) investigated the theoretical benefit of adding head blocks to a cervical collar when immobilising a patient with suspected spinal injury. Ten healthy volunteers were immobilised with four different combinations of external immobilisers: a long backboard only, a long backboard and cervical collar, a long backboard and head blocks, and lastly a long backboard, cervical collar and head blocks. The sample included subjects with various body shapes and BMIs. Cervical range of motion, as well as mouth opening, was measured in each combination using a digital inclinometer and the data sets were compared.

The greatest mean reduction in cervical range of motion was demonstrated when subjects were immobilised with a long backboard and cervical collar (34% of normal range). The reduction in motion did not increase when head blocks were added to the combination (p=>.05). A significant difference was noted when motion with the long backboard alone was compared to the long backboard and collar (p=<.005). The mean mouth opening was significantly reduced when a cervical collar was applied (p<.01). The author concludes that the addition of head blocks to a cervical collar for the immobilisation of suspected spinal injury is unnecessary and the practice should be reviewed. Furthermore, the reduction in mouth opening corroborates the theory that spinal immobilisation compromises airway management, a risk that should be carefully weighed against the benefit of immobilisation.

A systematic review by Holla et al. (2016:2023-2036) summarises the efficacy of external immobilisers in reducing cervical range of motion. The review included research outlining the degree of immobility achieved when compared to baseline movement. Only studies on healthy volunteers were included as well as articles published in English and German. Articles reporting the mean reduction in movement rather than immobility in each plane were excluded. A database search from inception to 2012 produced 13 relevant articles with a cumulative sample of 220 volunteers. The review authors classified all external immobilisers examined into categories based on the anatomical region that the immobiliser supports. Categories were defined as cervical devices, cervico-thoracic devices, cranial devices, cranio-thoracic devices for non-ambulatory patients and cranio-thoracic devices for ambulatory patients. Data from included articles were then converted into a mean restriction percentage, which was then used to calculate a minimal immobilisation limit (MIL). A narrative analysis describes the results.

Regarding cervical devices, soft collars demonstrated a poor ability to reduce cervical range of motion with a MIL of 0-22% and no relevant data were found for hard collars. Cervico-high thoracic devices demonstrated a moderate ability to reduce flexion-extension (MIL 42-78%), a poor to moderate ability to restrict lateral bending (MIL 13-40%) and axial rotation (MIL 13-40%). The ability of cervico-low devices to restrict mobility was moderate to high for flexion-extension (MIL 57-88%), poor to moderate for lateral bending (MIL 12-48%), and moderate to high for axil rotation (MIL 57-88%). Cranio-thoracic devices for ambulatory patients reduced mobility in flexion, lateral bending and axial rotation almost completely (MIL 74-92%), with a moderate to nearly complete ability to restrict extension (MIL 41-84%). The authors confirm the results substantiate the efficacy of cervical immobilisers, but highlight significant gaps in research regarding commonly used devices, such as the hard neck collar and the vacuum mattress. Further research is suggested to facilitate evidence-based decision making.

A retrospective chart review by Turnock et al. (2016:1-8) explores the association between spinal immobilisation and iatrogenic neurological injury in penetrating cervical trauma. The cohort included adult patients who presented to two American Level 1 trauma centres with penetrating neck trauma. The trauma registries from the

Louisiana State University (LSU) Health Sciences Center and the Hurley Medical Center (HMC) were screened for eligible patients admitted from 1994 to 2003 and 2000 to 2005 respectively. Primary outcomes of interest include the presence or absence of spinal immobilisation, neurological injury, cervical spine fracture, vascular injury and respiratory compromise. Direct penetrating brain injury was excluded from analysis.

The sample of 231 included 188 patients from LSU and 43 from HMC. Fifty-four-point-nine percent of patients from LSU and 11.2% from HMC were immobilised. Thirty-five patients from LSU and none from HMC demised. Of the total sample, 94 patients who survived to admission were immobilised, of which 16% had a spinal fracture and 8.5% (8 patients) were diagnosed with a spinal cord injury. Six out of eight spinal cord injuries were direct, and two were secondary, while 88% of these had an associated spinal fracture. Seven out of the eight patients with spinal cord injury were immobilised. Statistical analysis revealed cervical spine fracture as a significant risk factor for spinal cord injury ($p<.00001$). Major vascular injury correlated with brain injury ($p=.01$), but not with spinal cord injury ($p=.99$) or spinal fracture ($p=.67$). Furthermore, cervical spine immobilisation was a significant risk factor for secondary neurological injury ($p<.001$). In a discussion of results, it is highlighted that none of the patients who presented with secondary neurological injury had an unstable cervical spine fracture. The nature of these injuries included central cord ischaemia due to shock, cerebral vascular infarction due to interrupted arterial blood flow and central cord syndrome. The inference made is that spinal immobilisation in penetrating cervical trauma is inappropriate and possibly harmful.

In keeping with penetrating trauma, Velopulos et al. (2018:736-744) analysed published literature related to spinal immobilisation for this population in a systematic review. The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) methodology was followed to clarify enquiries regarding the association between spinal immobilisation and mortality, as well as neurological deficit and potentially reversible neurological deficit. Missed injury and failed intubation were secondary outcomes of the review. Research was eligible if it compared spinal immobilisation to no spinal immobilisation in adult patients with penetrating trauma. Randomised controlled trials, observational or retrospective

studies, and case-control studies published between 1980 and 2017 were sought via a systematic database search. Data from 24 relevant articles were entered into the RevMan Software. A meta-analysis was conducted on five of these while a narrative analysis synthesised the remaining articles. Recommendations were graded based on the quality of included studies and classified as “recommend” for high-quality research and “suggest” or “conditionally recommend” for weaker evidence.

Regarding mortality and neurological deficit, the meta-analysis favoured no immobilisation with a relative risk of 2.4 (CI=1.07-5.41) and 4.16 (CI=0.56-30.89), respectively. Regarding potentially reversible neurological deficit, the meta-analysis indicated no difference between spinal immobilisation versus no spinal immobilisation with a relative risk of 1.19 (CI=0.83-1.70). The narrative analysis found no advantage of spinal immobilisation for the mortality and neurological deficit. The evidence for the benefit that the intervention may provide for potentially reversible neurological injury was low. Furthermore, spinal immobilisation was associated with an increase in failed intubations, multiple intubation attempts, as well as time taken to intubate. In summary, the authors conclude that spinal immobilisation in penetrating trauma is associated with increased mortality and has little benefit in preventing a secondary injury. A strong recommendation follows to avoid the intervention as a routine practice for suspected spinal injury in this population.

An article by Fontaine et al. (2018:228-235) describes a practice improvement project implemented in an emergency department in Quebec, Canada. The CCR is a decision tool originally designed to accurately identify trauma patients with a suspected cervical spine injury who require radiological investigation. The sensitivity of the tool aims to rule out spinal injury based on clinical evaluation where possible, thereby eliminating unnecessary and potentially harmful radiography. The practice improvement project sought to train emergency nurses to use the CCR to identify patients unnecessarily immobilised by ambulance personnel and remove external immobilisation devices. An outcome of the project was to compare the accuracy of the nurses using the tool with that of emergency physicians. Following extensive research and preparation, a multi-disciplinary team was established to implement the project. Nine charge nurses were trained in the CCR, and intentional steps were

taken to encourage support and cooperation from the medical team. During a five-month period, all patients admitted to the emergency department in spinal immobilisation were referred to the charge nurse on duty who then assessed the indication for immobilisation based on the CCR. The patient information and assessment were recorded on a data capture form, and the decision to remove or retain immobilisation was corroborated by the physician on duty.

During the intervention period, 114 patients were assessed by nine charge nurses. As per the CCR criteria, only alert, orientated, stable patients were eligible. Spinal immobilisation was removed in 47% of patients and retained in 53% of patients. Furthermore, there was agreement between physicians and nurses 100% of the time. Reported benefits of the programme include increased patient comfort and decreased pain and anxiety, as well as decreased emergency department admission times and a lower rate of radiological investigations.

A similar programme was implemented on a larger scale in Ontario, Canada, and is reported in an article by Stiell et al. (2018:333-341). Described as a prospective cohort study, the project trained triage nurses in nine teaching hospitals to use the CCR as a decision tool to remove or apply spinal immobilisation as indicated. Primary outcomes included the clinical effect and the clinical safety of the intervention on patient care while secondary outcomes were nurse compliance and nurse comfort in using the CCR. The project was executed in two phases, the first being certification and the second implementation. Certification comprised of training a ‘site champion’ for each hospital in the use of the CCR by means of didactic and audio-visual presentations and simulations. In like manner, the site champions then trained the triage nurses of their respective departments. Upon appropriate assessment of 10 patients, triage nurses were certified and authorised to remove or apply spinal immobilisation based on CCR criteria. The implementation phase of the programme lasted 15 months, during which time certified nurses assessed alert and stable trauma patients with a suspected spinal injury arriving at the emergency department. Assessments were collected on data sheets which were kept in each department for 30 days in case any patient returned with a missed injury.

Nine hospitals enrolled in phase one of the project and one withdrew before the commencement of phase two. Hence, the following results are from eight emergency departments. In total, 2 229 patients were screened, and 1 408 patients were enrolled by 180 nurses. Eight-hundred-and-six patients were admitted by ambulance in spinal immobilisation, of which 41% had cervical collars removed, and there were no clinically important or missed injuries in this group. Fifty-nine percent of immobilised ambulance patients retained their collars. Of these, 0.7% were diagnosed with a cervical spine injury, 92 patients arrived by ambulance and presented with neck pain but were not immobilised, and 21% of this group had cervical collars applied by nurses; 3% were diagnosed with clinically important injuries.

Five hundred and ten patients arrived ambulatory and presented with neck pain, of which 36% had neck collars applied. Clinically important injuries were diagnosed in 1.2% of this group, and there were no missed injuries reported in ambulatory patients who did not have collars applied. Clinically important injuries were confirmed in 16 patients and included cervical spine fractures, ligamentous injuries and central cord contusions. Emergency department admission time was 3.8 hours for patients who had spinal immobilisation removed versus 4.9 hours for those who did not. Most nurses were very comfortable (43.9%) using the CCR, while 1.3% of nurses reported they were uncomfortable or very uncomfortable using the tool. The study substantiates the notion that emergency nurses can accurately use the CCR to assess patients with suspected spinal injury. Although significant training and collaboration are required for the success of such a programme, there is benefit in reduced admission times and improved patient care.

5.4 POPULATION, CONCEPT, CONTEXT

The guideline by the ESC Methods Programme (Popay et al., 2006:14) describes exploring relationships across studies as an important step in the review process. This element facilitates understanding through the identification and description of similarities and differences across studies. A relationship of interest highlighted by the guideline is that of characteristics of studies. To remain relevant and consistent, these relationships were explored within the same framework used to build the

research question for the review. Data regarding the population, concept and context of each study were extracted and is summarised in the concept map presented in Figure 5.2.

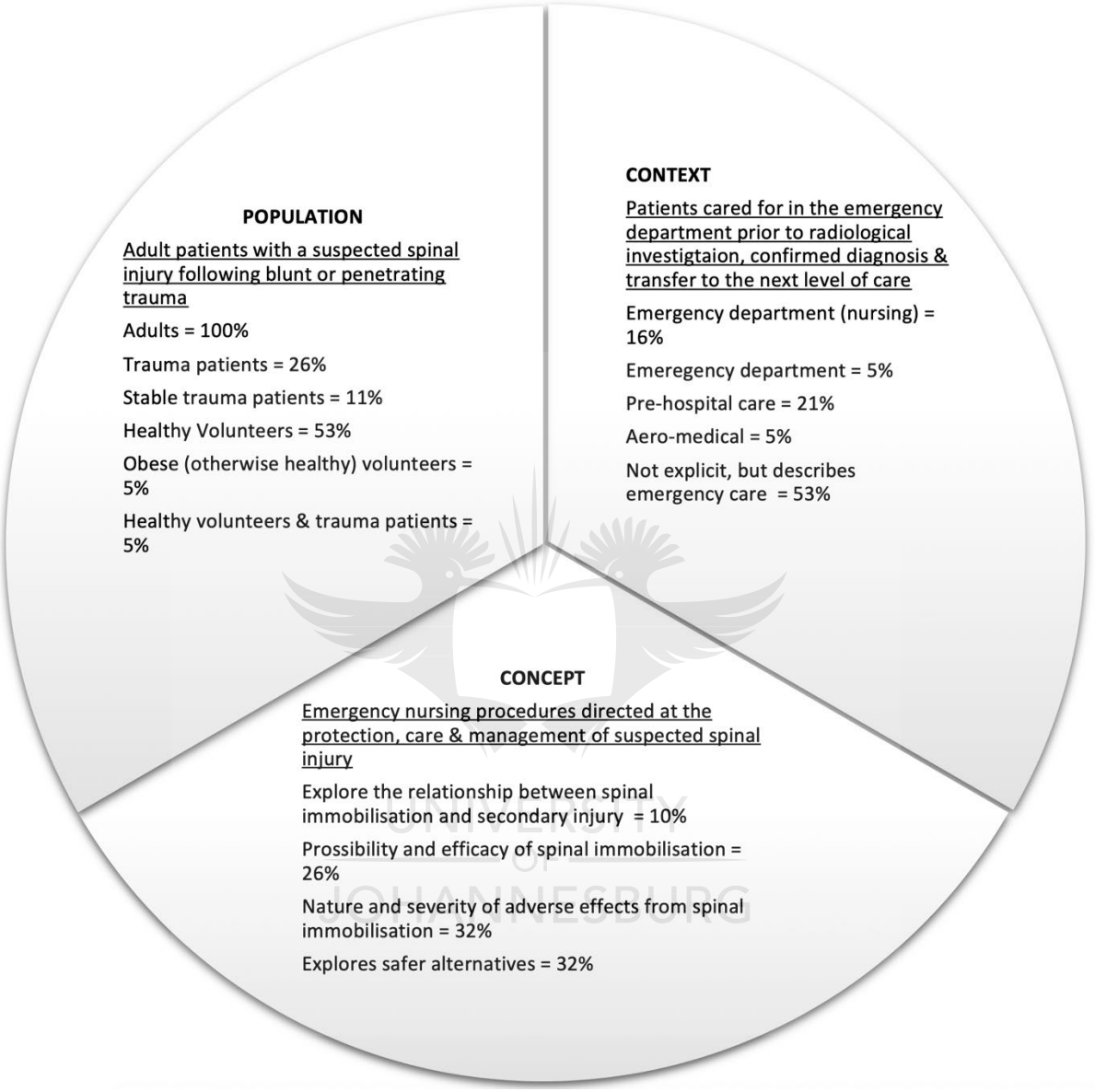
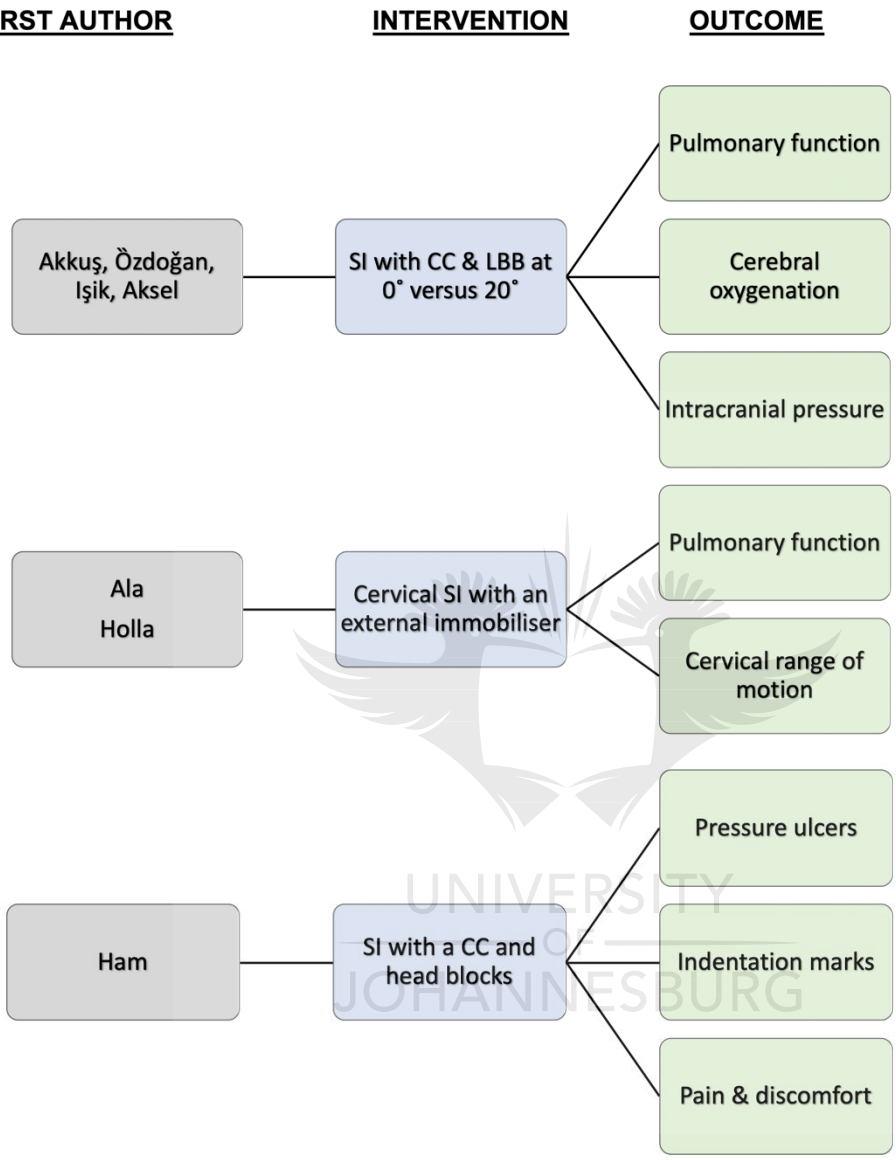


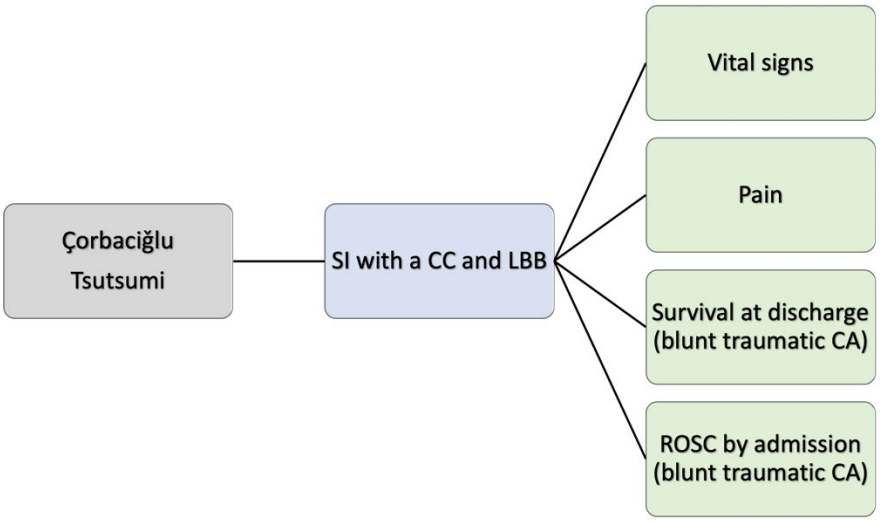
Figure 5.2: Characteristics of Studies: Population, Concept, Context

5.5 INTERVENTIONS AND OUTCOMES EXPLORED

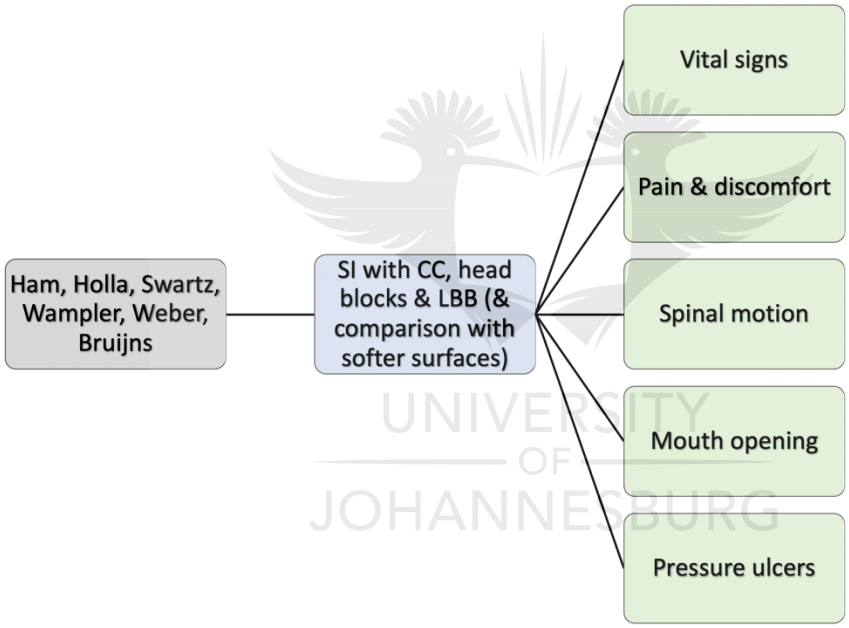
A second relationship of interest highlighted by the ESRC Methods Programme is that of the findings of studies (Popay et al., 2006:14). Although significant variability is evident across included studies, an agreement was detected in the outcomes explored. Idea webbing was the suggested tool utilised to explicate this pattern. Studies are broadly grouped based on how the intervention was defined and

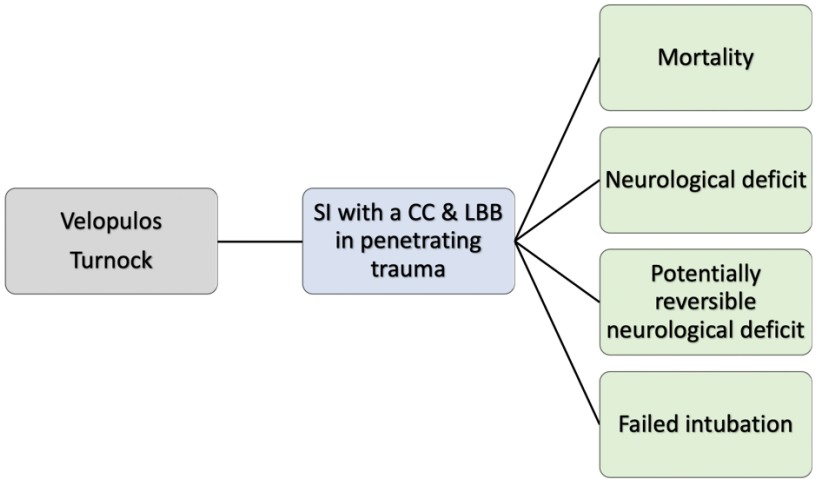
implemented, and a diagram illustrates the common outcomes investigated within each group. The outcomes highlighted in this method of analysis are used as a basis for thematic synthesis, the next step in the process of analysis.

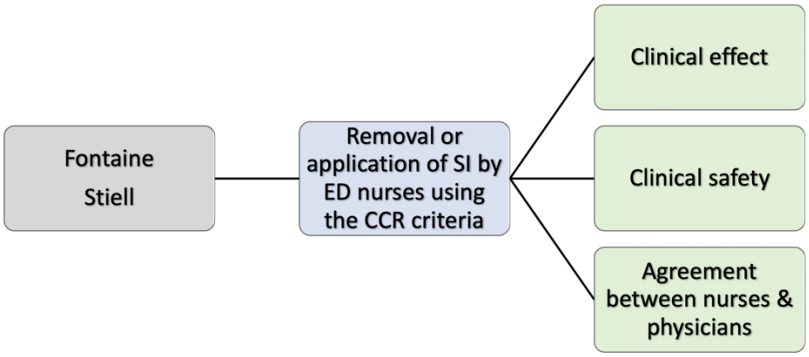




FIRST AUTHOR **INTERVENTION** **OUTCOME**







SI – spinal immobilisation **CC** – cervical collar **LBB** – long backboard **CA** – cardiac arrest **ED** – emergency department **CCR** – Canadian C-spine rule

Figure 5.3: Findings of Studies: Interventions and Outcomes

5.6 THEMATIC ANALYSIS

5.6.1 Pulmonary Function

Three studies examined pulmonary function as an outcome of interventions directed at suspected spinal injury, of which two included healthy volunteers and one included trauma patients. The two studies involving volunteers (Akkuş et al., 2016:1959-1962; Işik et al., 2019:1-5) considered the variable in relation to spinal immobilisation in a revised position with the head elevated to a 20-degree angle. One of these studies included only volunteers with normal BMI's and the other included only volunteers with android-type obesity. The only positive outcome was an FVC comparable to baseline values in the group with normal body weight. All other measures of spirometry were decreased for this group, while no beneficial outcome was demonstrated in the obese group. In addition, for the purpose of comparison, spirometry was also measured in the regular spinal immobilisation position. All measures were decreased at 0-degrees for both groups when compared to baseline values.

The study conducted on trauma patients (Ala et al., 2016:657-660) yielded significantly lower values in all measures of respiratory function when a cervical collar was in place compared to values obtained after collar removal. The article reporting this research does not describe the position in which spirometry was tested, and there is no mention of other immobilising devices in place. This is a detail that may have influenced the outcome as lung capacity in a seated position differs

from that in a supine position. Quality appraisal revealed this element of minimising bias in the exposure appears to be muddied in all three articles. Furthermore, confounding variables are neither identified nor accounted for in the analysis of data. A further limitation is the extrapolated data from healthy volunteers and the constraints of using these conclusions to make inferences about injured patients.

That said, there is regularity in the findings as all three studies detected a marked decrease in pulmonary function in the presence of spinal immobilisation. Taking the study weaknesses into account, the consistency seems to suggest that compromised lung capacity due to spinal immobilisation is a noteworthy consideration; especially in patients who may have sustained chest trauma as well as patients who are at risk for hypoxia due to shock.

5.6.2 Airway Management

Two studies included aspects of airway management as secondary outcomes in the analysis of spinal immobilisation. Holla (2012:104-107) measured mouth opening in 10 healthy volunteers immobilised with a cervical collar and compared the value to a baseline measurement. Mean mouth opening without an external immobiliser was 47mm and 34mm with a cervical collar in place. The difference was considered significant ($p<.01$), suggesting the device compromises airway management.

A systematic review by Velopulos et al. (2018:736-744) questioned the value of pre-hospital spinal immobilisation in penetrating trauma. Results established an association between the intervention and an increase in failed intubation attempts, multiple intubation attempts, and time taken to intubate.

Appraisal based on the CASP checklist revealed high-quality evidence for the systematic review and some vagueness in the reporting of bias and adjustment for confounders for the cohort study. Results are consistent in the deduction that spinal immobilisation may impede airway management.

5.6.3 Vital Signs

The effect that interventions directed at suspected spinal injury has on vital signs was investigated as a primary outcome in two studies and a secondary outcome in one study. All research was conducted in simulated scenarios on healthy volunteers. One study (Çorbacioğlu et al., 2016:65-68) compared blood pressure, heart rate, respiratory rate and oxygen saturation in subjects immobilised with a long backboard and collar to baseline measures taken 30 minutes prior to immobilisation. The other two studies (Bruijns et al., 2013:210-214; Swartz et al., 2018:630-636) measured vital signs at regular intervals during a simulation designed to mimic clinical management of a suspected spinal injury. In both of these studies, the values were compared to each other as well as to baseline values and statistically analysed.

Bruijns et al. (2013:212) reported a statistical difference in results for blood pressure, heart rate and respiratory rate when the values were compared within data sets. However, when analysed in relation to the pre-determined relevant outcome measure, results were not clinically meaningful, and the authors concluded that spinal immobilisation has no significant effect on vital signs. Çorbacioğlu et al. (2016:66) found a significant decrease in systolic blood pressure following spinal immobilisation. No significant difference was observed for any other vital sign. Regarding the quality of this research, there is no mention of confounding variables identified or adjusted for in either of the prospective cohort studies. Furthermore, reporting of methods do not clarify how bias was minimised in the exposure for both studies and in outcome measurement for the study by Çorbacioğlu et al. (2016:65-66).

Swartz et al. (2018:634) reported a higher systolic blood pressure as a secondary outcome of traditional spinal immobilisation in a simulated scenario. Described as a counterbalanced crossover design, this study was appraised according to the CASP tool for randomised controlled trials. There is control of the intervention and the comparison, however the authors state that blinding was not possible due to the nature of the study. The quality of evidence and conflicting results across these three studies invalidates the notion that spinal immobilisation negatively influences vital signs. The contrast is noted in the discussion by Çorbacioğlu et al. (2016:67), who confirms that more robust research on larger samples is necessary to identify a relationship between spinal immobilisation and vital signs.

5.6.4 Pain

Pain associated with spinal immobilisation was described in six studies. The variable was explored as a primary outcome in two studies and as a secondary outcome in the other four studies. Only one study (Ham et al., 2016:1924-1931) examined pain in trauma patients. From a cohort of 288 patients immobilised with cervical collars and head blocks, 63.2% reported pain on a 10-point numeric rating scale. Within this group, pain was rated as mild by 16.7%, moderate by 24.6%, and severe by 38.5%, and was most frequently experienced on the occiput. In a discussion regarding the implication of pain in patients with a suspected spinal injury, the authors describe anecdotal evidence that pain causes irritability and a desire to move to relieve the pressure that causes pain. The resulting cervical spine movement is paradoxical to the purpose of the collar and head blocks. In addition, the clinical bias that often results from the presence of spinal immobilisation is highlighted as well as the unnecessary radiological investigations that may ensue. This study was awarded an affirmative answer for every question in the CASP checklist, indicating a high quality of evidence.

Bruijns et al. (2013:210-214) examined pain as a primary outcome in a cohort of healthy volunteers subjected to spinal immobilisation and log-roll. Statistical analysis revealed a significant difference between baseline pain and pain with spinal immobilisation, but with a small effect size of 0.13. The reason pain was measured in this study was to explore a correlation between this outcome and vital signs in the presence of external immobilisers. No clinically meaningful relationship was demonstrated, nonetheless, the incidence of pain seems worth noting. Total time that volunteers were immobilised was 20 minutes. There was some difficulty identifying how the authors minimised bias and identified confounding variables, although the simulation that volunteers were exposed to does not appear to include other causes of pain.

In four studies conducted on healthy volunteers, pain was described as a secondary outcome and was measured by either a 100-point VAS or a 10-point verbal rating scale. Çorbacioğlu et al. (2016:65-68) report a significant increase in pain in the back

and neck after 30 minutes of spinal immobilisation with a cervical collar and head blocks. Swartz et al. (2018:634) report a pain rating in 40% of subjects immobilised on a long backboard and in 25% of subjects immobilised on an ambulance stretcher. Weber et al. (2015:213-217) measured discomfort from reported pain and describe an increase in scores after immobilisation on a backboard or padded litter when tilted left and right at 45 degrees. The authors state that the ratings were so low that they were not significant, but also note that the mean time immobilised of 5.5 minutes may not have been long enough to elicit pain. Wampler et al. (2016:717-721) describe no difference in pain scores between subjects immobilised on a long backboard compared to those on a stretcher mattress. The article does not compare the outcome against baseline pain scores, and a discussion concedes that the exposure time of 10 minutes may be unrealistically short and the results should be considered with this in mind. The quality of these studies varied, with some weaknesses and limitations. However, an increase in pain seems consistent following spinal immobilisation, with non-significant results demonstrated in research on healthy volunteers with a small sample and short exposure time.

5.6.5 Pressure Ulcers and Indentation Marks

Two studies examined pressure ulcers and indentation marks from prophylactic spinal immobilisation for suspected spinal injury, one prospective cohort on trauma patients and one systematic review. The systematic review (Ham et al., 2014:1131-1141) exploring the incidence and severity of pressure ulcers from spinal immobilising devices reviewed 13 primary articles with an aggregated sample size of 11 180. Of the included studies, four were observational studies conducted on trauma patients and nine were experimental studies conducted on healthy volunteers. The review yielded an incidence of pressure ulcers due to cervical collars between 6.8% and 38%. Pressure from collars resulted in ulcers at stage 1, 2, 3 and 4 and originated on the occiput, chin, suprascapular, shoulders and clavicle. Risk factors associated with pressure ulcer development were length of time immobilised, an indication for magnetic resonance imaging, mechanical ventilation, a high ISS, increased BMI, as well as increased skin temperature and skin humidity. Preventative measures are also discussed and include regular skin inspection, collar refit and position change. Early diagnosis or exclusion of injury will also lead to early

removal or replacement of temporary immobilisation, another important preventative measure. Relevant articles were critically appraised using the research appraisal checklist (RAC) for nursing reports. Seven articles were described as superior quality while six were described as average quality. The systematic review itself was awarded an affirmative answer for each point on the CASP checklist for systematic reviews, indicating rigorous research.

A prospective cohort study (Ham et al., 2016:1924-1931) investigated the incidence and severity of pressure ulcers and indentation marks in trauma patients immobilised in an emergency department awaiting diagnosis or exclusion of spinal injury. In a cohort of 342 patients who spent a mean time of 117 minutes immobilised in a cervical collar and head blocks, 78.4% presented with pressure ulcers; 75.4% had a category 1 ulcer as the most severe, while 2.9% had category 2 as the most severe. Pressure ulcers were located on the chest, back and shoulders. Sixty-four-point-six percent of patients from the same group presented with indentation marks from cervical collars, of which 28.1% were graded as severe. Quality appraisal indicates a rigorous methodology was used for this study, likely producing valid and reliable results. These two studies, different in design but with similar objectives, were conducted by the same authors. The cohort study was performed in a level 1 emergency centre in the Netherlands which is a country with reasonable resources at its disposal. The systematic review included populations with diverse characteristics. Results from the two studies correlate and suggest a significant risk of pressure ulcer development from spinal immobilisation.

5.6.6 Central Nervous System

For the purpose of a thematic analysis, all outcomes relating to the central nervous system (CNS) were grouped together. CNS outcomes from interventions directed at suspected spinal injury were examined by two prospective cohort studies on healthy volunteers (Aksel, 2018:84-87; Özdoğan et al., 2019:1327-1330), one retrospective cohort study on trauma patients (Turnock et al., 2016:1-8), and one systematic review including trauma patients (Velopulos et al., 2018:736-744). Outcomes include cerebral oxygen saturation, intracranial pressure and neurological injury.

Cerebral oxygenation was measured by Aksel (2018:84-87) in healthy volunteers immobilised with a cervical collar and long backboard at 0-degree versus 20-degree angles. Values were slightly lower at 20 degrees compared to 0 degrees, but the results were not statistically significant, and the authors therefore concluded that there was no difference. The objective of the study was to assess the effect of spinal immobilisation at 20 degrees on cerebral oxygenation. As such, there is no comparison of the outcome against baseline values, the implication being that the effect that spinal immobilisation at 0 degrees has on cerebral oxygenation cannot be determined from this research. The deduction made from the study is that spinal immobilisation in a modified position with the head elevated at 20 degrees is safe with regards to cerebral oxygenation. The article does not detail how bias was minimised regarding the exposure, and it is not clear whether adjustments were made for confounding variables.

A similar study (Özdoğan et al., 2019:1327-1330) investigated intracranial pressure in healthy volunteers immobilised with a cervical collar and long backboard at 20 degrees versus 0 degrees. An alteration in intracranial pressure was derived from the ultrasonographic measurement of left and right optic nerve sheath diameter. Contrary to the article on cerebral oxygenation, this study compares the outcome against baseline measurements taken in the 0^{th} minute of immobilisation. Measurements were also taken at 30 and 60 minutes for each position and comparisons made within and between data sets. Results demonstrated a significant increase in optic nerve sheath diameter, and therefore intracranial pressure, over time in both positions. There was no significant difference between the two positions. The report lacks clarity regarding how potential bias was managed or whether statistical analysis considered confounding variables.

A retrospective chart review (Turnock et al., 2016:1-8) of two level 1 trauma centres generated a cohort of 196 patients with penetrating neck trauma who survived to discharge. The authors investigated an association between cervical spine immobilisation and neurological injury in this group. Eight patients (8.5%) presented with primary cervical spinal cord injury, of which 88% were associated with a cervical spine fracture and all were immobilised. Two of these patients presented with an unstable cervical spine fracture; they were also the only patients (1%) in the entire

cohort with this injury, and both had non-salvageable complete neurological fallout. The authors therefore deduce that spinal immobilisation served no purpose for these patients.

Four patients (2%) were diagnosed with secondary neurological injury. Two patients suffered a right cerebrovascular infarction due to interrupted carotid artery blood flow. Two patients suffered cervical spine cord injury, one from central cord syndrome and one due to ischaemia secondary to shock. Based on these results, the authors calculated the indication for cervical spine immobilisation at 0% for this cohort. Furthermore, statistical analysis demonstrated that cervical spine immobilisation was associated with an increased risk for secondary neurological injury. This could possibly be explained by the complications of vascular injury outweighing the complications of spinal fracture in this group.
An outcome explored by the study, but not explicitly relevant to the present systematic review, was the incidence of vascular injury in the population of interest. The article reports an 11% incidence of major vascular injury and a 3.1% incidence of primary cervical spine injury in the sample. The deduction made is that the delay in transport time, concealment of injuries, compromised airway and increased intracranial pressure that may result from spinal immobilisation compromises the management of vascular injury in penetrating neck trauma.

A systematic review (Velopulos et al., 2018:736-744) including 24 quantitative studies examined spinal immobilisation in an aggregated sample of 155 089 patients with penetrating trauma. A qualitative analysis revealed that no study found any benefit of spinal immobilisation for neurological injury or potentially reversible neurological injury. Quantitative synthesis of four included studies was conducted for both of these outcomes in the form of a meta-analysis. No statistical difference was found between spinal immobilisation and no spinal immobilisation for either outcome. However, the authors highlight significant variability across synthesised studies and suggest this to be a factor contributing to the lack of statistical significance.

A CASP evaluation of the systematic review revealed a rigorous methodology and the large aggregated sample is likely to provide reliable results. Reporting of bias control and adjustment for confounders was clouded in the retrospective chart review

by Turnock et al. (2016:1-8). Nonetheless, conclusions from the two studies are congruent. No evidence demonstrated that prophylactic spinal immobilisation benefits primary or secondary neurological injury in penetrating trauma. In addition, analysis revealed that immobilised patients from this population were more likely to suffer secondary neurological injury than those who were not. Utilising the GRADE methodology, Velopulos et al. (2018:736-744) recommend against routine spinal immobilisation in penetrating trauma as it provides no benefit in preventing neurological injury.

5.6.7 Mortality

Three studies investigated the relationship between spinal immobilisation and mortality. While all three studies were conducted on trauma patients, one examined the outcome in blunt trauma, and the other two focused on penetrating trauma. In a retrospective cohort study, Tsutsumi et al. (2018:124-129) measured the rate of survival at discharge in blunt trauma patients presenting with on-scene cardiac arrest who were immobilised, to those who were not immobilised. A cohort of 4 313 patients was generated by a chart review from the Japan Trauma Data Bank over an 11-year period. Of the sample, 76.7% were immobilised, and 23.3% were not immobilised. Of immobilised patients, 1.8% survived to discharge, while 3.7% from those who were not immobilised survived to discharge. As a secondary outcome, the authors compared the rate of ROSC by admission in the same two groups. ROSC was achieved in 25.0% of patients who were immobilised and 41.9% of patients who were not immobilised. Data collected regarding confounding variables revealed that patients who were immobilised had a higher ISS and a higher proportion of chest injury. There was also no significant difference in time from the emergency services' arrival on scene to hospital admission. Despite this, a statistical analysis that adjusted for covariates displayed immobilised patients had a lower chance of survival by discharge (OR 0.64) and a lower proportion of ROSC by admission (OR 0.48). This study met all criteria in the CASP checklist, indicating a high quality of research and reliable results.

Regarding penetrating trauma, mortality was explored in a retrospective chart review (Turnock et al., 2016:1-8) and in a systematic review (Velopulos et al., 2018:736-

744). In a total cohort of 231 patients with penetrating neck trauma, 35 patients demised. Seven of these deaths occurred in the pre-hospital phase, of which six were immobilised. Eighteen patients died in the emergency department, of which 13 were immobilised. Ten patients died after hospital admission, of which eight were immobilised. Causes of death included cardiac arrest, haemorrhage and traumatic brain injury. Of the 35 patients who demised, six presented with a cervical spinal cord injury, all of which were immobilised. The article does not describe a statistical analysis on mortality beyond the incidence reported. A qualitative synthesis (Velopulos et al., 2018:739) of 24 studies showed no benefit of spinal immobilisation in penetrating trauma for the mortality. A meta-analysis of four studies (Velopulos et al., 2018:742:740) found spinal immobilisation in penetrating trauma was associated with an increase in mortality with a relative risk of 2.4 (CI 1.07-5.41). Evidence from the three studies investigating the relationship between mortality and spinal immobilisation is of average to high quality. The message conveyed is that pre-hospital spinal immobilisation correlates with a lower chance of survival and a lower proportion of ROSC by admission for blunt trauma victims in cardiac arrest. Furthermore, the intervention may contribute to a higher rate of mortality in penetrating trauma.

5.6.8 Range of Motion

Five studies considered range of motion (ROM) as an outcome of spinal immobilisation, all of which were conducted on healthy volunteers. A cohort study and a systematic review measured the restricted cervical ROM provided by external immobilising devices. Two randomised controlled trials and a cohort study compared the amount of cervical, thoracic and lumbar shift permitted between two different devices.

Studies regarding cervical ROM assessed the degree of movement in three planes, namely flexion-extension, lateral bending and axial rotation. Holla (2012:104-107) evaluated whether a cervical collar and head blocks provide greater cervical immobilisation than head blocks alone. Mean ROM for flexion-extension when subjects were immobilised with only a cervical collar was 55 degrees, and 6 degrees for only head blocks, while the combination allowed 4 degrees ROM in this plane.

Mean ROM for lateral bending was 40 degrees with a cervical collar alone, 10 degrees for head blocks alone, and 12 degrees for the combination. Mean ROM for axial rotation was 53 degrees for cervical collar alone, 8 degrees for head blocks alone and 6 degrees for the combination. Statistical analysis revealed a significant difference in mean cervical ROM between the two devices, with head blocks reducing motion significantly more than the collar. In addition, no significant difference was observed in mean values between head blocks alone and the combination of a cervical collar and head blocks.

A systematic review (Holla et al., 2016:2023-2036) analysed the efficacy of categorised external immobilisers in reducing cervical motion. Regarding devices commonly utilised in an emergency department, a poor MIL of 0-22% was calculated for the soft cervical collar, while insufficient evidence impeded quantification of a MIL for the rigid cervical collar. Devices such as the Miami J, Stifneck, Philadelphia and Aspen brace were categorised as cervico-high thoracic devices and were found to reduce flexion-extension with a MIL of 42-78% and lateral bending and axial rotation with a MIL of 13-40%. Considering the limitation of extrapolated data, results from the two studies appear to indicate that cervical collars are not completely efficient in reducing cervical motion, and that head blocks alone may be of more value in achieving this outcome. Critical appraisal demonstrated an average quality of evidence with uncertainty regarding the role of confounders in the cohort study and inclusion of relevant articles in the systematic review.

Swartz et al. (2018:630-636) compared three-dimensional spine ROM in subjects immobilised on a long backboard with a cervical collar and head blocks (traditional spinal immobilisation), to those immobilised on a stretcher mattress with a cervical collar alone (spine motion restriction). Peak ROM in the frontal plane was 15.3 degrees for traditional spinal immobilisation, and 14.9 degrees for spine motion restriction. In the sagittal plane, peak ROM was 15.7 degrees for traditional spinal immobilisation and 14.7 degrees for spine motion restriction. Peak ROM in the transverse plane was 10.9 degrees for traditional spinal immobilisation, and 9.6 degrees for spine motion restriction. Statistical analysis revealed no significant difference between the two methods for flexion-extension and lateral bending, but greater mean axial rotation in traditional spinal immobilisation.

Wampler et al. (2016:213-217) compared lateral motion of the head, torso and pelvis in volunteers subjected to traditional spinal immobilisation to those immobilised on a stretcher mattress with a cervical collar and head blocks. Traditional spinal immobilisation permitted a greater lateral motion of 0.5cm in the head, 1.7cm in the torso and 0.8cm in the pelvis. An aggregated mean greater lateral shift of 0.8cm was calculated for traditional spinal immobilisation when compared to immobilisation on a stretcher mattress. There was also a direct correlation between a higher BMI and lateral shift demonstrated for both methods of immobilisation.

Weber et al. (2015:717-72) also compared lateral motion of the head, torso and pelvis between volunteers in traditional spinal immobilisation to those immobilised on a softer surface. However, the exposure included a 45-degree left and right tilt to simulate the kinetics of air medical transport in a helicopter. When tilted to the right, traditional spinal immobilisation allowed a shift of 1.45” in the head, 3.91” in the sternum, and 4.07” in the pelvis. A left tilt of volunteers in traditional spinal immobilisation resulted in a shift of 1.24” in the head, 3.93” in the sternum, and 4.24” in the pelvis. To contrast, the padded surface permitted a shift of 1.4” in the head, 3.1” in the sternum, and 3.2” in the pelvis when tilted to the right. A left tilt of the padded surface allowed a shift of 1.36” in the head, 2.93” in the sternum, and 2.9” in the pelvis. An analysis of these results indicated significantly greater motion in the sternum and pelvis for volunteers immobilised on the padded surface, but no significant difference in head shift. A discussion underlines that there was significantly greater movement in the sternum and pelvis compared to the head for both devices. This is attributed to the lateral blocking created by the head blocks and the increase of torque by the lack of blocking in the sternum and pelvis.

The studies examining spinal motion in the head, sternum and pelvis can be described as average quality, with relatively small sample sizes (20, 9 and 42 respectively). Swartz et al. (2018:636) acknowledge the absence of blinding in their trial and cite the nature of the research as a rationale. Wampler et al. (2016718) blinded ambulance drivers, but not study observers, while Weber et al. (2015:213-212) lacks clarity regarding the adjustment of confounding variables. Despite limitations, the studies appear to corroborate the notion that the head blocks may be

sufficient for immobilising the cervical spine and that the benefits of the long backboard do not outweigh harms.

5.6.9 The Canadian C-spine Rule

Two studies explored equipping emergency nurses to use the CCR as a decision tool to remove or apply immobilisation devices in trauma patients with suspected spinal injury. Outcomes from these studies are discussed separately as the intervention is markedly different from those explored by the other included articles, which broadly measure outcomes from spinal immobilisation itself. Fontaine et al. (2018:228-235) and Stiell et al. (2018:333-341) describe two similar practice improvement projects implemented in separate states in Canada. Emergency nurses were trained and authorised to determine the presence or absence of an indication for spinal immobilisation based on the criteria of the CCR. Based on this assessment, nurses either removed or applied immobilisation devices. Outcomes evaluated are classified as clinical effect and clinical safety. Clinical effect includes the measure of patients who had cervical collars removed, left in place or applied, as well as length of stay in the emergency department. Clinical safety includes consensus in assessments between nurses and physicians, missed injuries, and adverse effects. Nurse compliance and comfort in utilising the CCR in the clinical arena was also assessed.

In a single facility, nine nurses assessed 114 trauma patients with suspected spinal injury over five months (Fontaine et al., 2018:228-235). Of this group, 47% had cervical collars removed based on the CCR criteria, while 53% retained their cervical collars. Consensus between nurses and physicians regarding clinical assessment and decision was 100%. Concerns raised by nurses in the study include the time-consuming nature of the assessment, apprehension regarding the safety of the tool used in the clinical environment, and a lack of standardised reporting of assessments and decisions. The authors cite these aspects as limitations that should be noted in future projects and encourage innovative means for resolution. An increased patient comfort and satisfaction, shorter emergency department length of stays, and a lower rate of radiological imaging are beneficial implications

discussed, although numerical results for these outcomes are not provided. Furthermore, the article does not report on missed injury.

A multi-facility project included 1 408 trauma patients with suspected spinal injury enrolled by 180 nurses (Stiell et al., 2018:333-341). Of this group, 898 patients arrived by ambulance, and 510 arrived ambulatory. Eight-hundred-and-six ambulance patients arrived immobilised, of which 41% had their collars removed, and 59% (475 patients) retained their collars. Ninety-two ambulance patients arrived with neck pain but without spinal immobilisation, of which 21% (19 patients) had immobilisation applied. Three out of these 19 patients were diagnosed with a spinal injury, along with seven out of 475 ambulance patients who retained immobilisation. All ambulatory patients arrived with neck pain but without spinal immobilisation. Of these, 63% did not have, and 36% (184 patients) did have, spinal immobilisation applied. Six out of 184 were diagnosed with spinal injuries. No missed injuries were reported among patients who had their collars removed or patients who did not have immobilisation applied. No adverse outcomes were reported for the project. Ambulance patients who had their collars removed spent 1 hour less time in the emergency department compared to those who did not have collars removed. Overall, the comfort and compliance of nurses utilising the CCR were rated as very comfortable and good, respectively. This study did not measure consensus in clinical judgement between nurses and physicians.

Quality assessment revealed that both studies appear to have been well conducted, with the only area of uncertainty being the reporting of confounding variables. That said, due to the nature of the research, neither studies performed a statistical analysis, and therefore a confounder adjustment would not have been relevant. Results suggest training and authorising emergency nurses to use the CCR to remove or apply spinal immobilisation in trauma patients with suspected spinal injury is feasible, safe and beneficial.

5.7 CONCLUSION

This narrative synthesis was guided by the framework and tools presented in the ESRC Methods Programme (Popay et al., 2006:11-23). The four elements of

systematic synthesis were followed in an iterative manner to produce an evidence base from the results of the 19 included studies.

Firstly, a theory of change, based on information consistently found in the background of relevant articles, describes key aspects related to the intervention. Textual descriptions describe key aspects of such research that is specifically relevant to the systematic review. The process of using words to systematically describe each study unveiled patterns and relationships across included articles. These relationships are illustrated in concept maps that compare variability and similarities. Agreement in the outcomes was revealed in the process of synthesis, even when the definition of the intervention varied to some degree. These outcomes form the framework of thematic analysis, along with a discussion of the quality of included studies to mitigate the absence of weighting of research.

Pulmonary function, airway management, vital signs, pain, pressure ulcers, neurological injury, mortality and ROM are common outcomes that overlap across relevant studies. In addition, two studies explore the clinical effect and safety of equipping emergency nurses to use the CCR as a decision tool in the presence of suspected spinal injury from trauma. Chapter Six provides a discussion of the results and limitations of the included studies and methodology. Recommendations for nursing practice, based on the results, are also presented.

CHAPTER SIX
DISCUSSION, LIMITATIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

A systematic methodology was followed to answer the question 'What emergency nursing interventions used in blunt and penetrating trauma patients with suspected spinal injury produced the best patient outcome?'.

Standardised processes were employed to systematically identify, examine and evaluate relevant primary research. Every attempt was made to be rigorous in fulfilling each step of the review process to produce accurate and reliable results. Bias was addressed by striving for a comprehensive search, following accepted methodology and consulting with an independent expert. The quality of the included studies was appraised and extracted data were synthesised to produce a body of information.

This chapter serves to balance inferences from synthesised results with other evidence for comparison and contrast. A discussion regarding the limitations of included studies and the review process follows, as well as the implication this has on conclusions. In fulfilment of the second objective of this study, recommendations

regarding nursing interventions for suspected spinal injury that are likely to produce the best patient outcome, based on the synthesised evidence, are tabulated.

6.2 SUITABILITY OF EVIDENCE IN ANSWERING THE RESEARCH QUESTION

Research related to the emergency care of suspected spinal injury following blunt and penetrating trauma was pursued to answer the research question. An electronic database search using search terms derived from the question yielded an enormous list of results. Applying the eligibility criteria to this list initially identified 60 relevant articles. This number, far higher than anticipated, was deemed unmanageable and inappropriate for the scope of this review. Consequently, the sample was further refined based on the input of an external reviewer.

The abundance of literature was most likely on account of the broad research question and limiting the sample to a practicable size may have omitted studies exploring common outcomes. Despite the sample not being entirely comprehensive, endeavours to adhere to accepted methods place some confidence in the body of evidence produced by the review. As such, conclusions can be drawn on to enlighten South African emergency nurses to weigh the benefit versus harm produced by spinal immobilisation.

6.3 DISCUSSION OF MAIN RESULTS

Empirical research exploring interventions directed at the care and protection of a suspected spinal injury was particularly diverse and difficult to synthesise. Nonetheless, analysis of extracted data detected consensus on several aspects. Results revealed that spinal immobilisation devices cause pain, pressure ulcers, indentation marks and increase intracranial pressure while compromising pulmonary function and airway management. There is, however, some suggestion that these adverse effects are not severe enough to significantly alter vital signs.

In penetrating trauma, spinal immobilisation was associated with an increased probability of secondary injury and increased mortality. In addition, no relationship

was found between spinal immobilisation and the prevention of a complicating primary injury in this population group.

Although findings from studies testing the efficacy of spinal immobilisation varied somewhat, there appears to be a lack of evidence substantiating the adequacy and safety of the cervical collar. While head blocks provided the greatest reduction in cervical ROM, the long backboard did not demonstrate superior ability to immobilise over softer devices.

Equipping nurses to use the CCR as a decision tool to remove and apply spinal immobilisation in stable trauma patients with suspected spinal injury proved to be clinically effective and safe. A multi-centre implementation of this intervention demonstrated advantages for the patients as well as cost and time management benefits.

6.4 CORRELATION OF FINDINGS TO OTHER EVIDENCE

6.4.1 Current Practice

A recent structured review of literature offers recommendations regarding spinal immobilisation for the South African pre-hospital environment (Stanton et al., 2017:4-8). An intentional patient assessment is advocated as a starting point to accurately recognise an indication for intervention. This encouragement of clinical judgement seems to disregard the routine suspicion for spinal injury in all trauma patients. The recommendations further deal with patient handling, extrication from a vehicle, cervical spine management, and restricting motion during transport. The guideline advises against the log-roll, Kendrick Extrication Device, cervical collar and the use of the long backboard as a transport device. The unit lift, self-extrication of sober and stable patients, head blocks only and the vacuum mattress, scoop or ambulance stretcher are endorsed as alternatives. Additionally, spinal motion restriction is not advised in penetrating trauma as rapid transport to definitive care takes precedence.

The guideline by Stanton et al. (2017:4-8) provides valuable guidance for the care of a trauma patient on scene and during transport. To our knowledge, no national guideline directing emergency nursing interventions related to a suspected spinal

injury has been disseminated in South Africa. While this best practice recommendation may provide some direction, it is not explicitly intended for nursing care in an emergency department. International guidelines for the management of a trauma patient have been established by the American College of Surgeons and are presented in the ATLS® course (American College of Surgeons, 2018:vii). Although instruction provided in the programme is directed at medical doctors (American College of Surgeons, 2018:xxix), as members of the resuscitation team and in the absence of nurse specific guidelines, ATLS® often provides a broad guideline for nursing injured patients.

ATLS® teaches a systematic approach to trauma care that prioritises assessment and management of that which is deemed most life-threatening (American College of Surgeons, 2018:xxxvi). The first and most important step to this process is maintaining airway patency and restricting cervical spine motion. Explication of this principle encourages an assumption of cervical spine injury based on the mechanism of trauma. Practitioners are further advised to prevent deterioration of such an injury by immobilising the cervical spine with a cervical collar (American College of Surgeons, 2018:7-8). No distinction is made between blunt and penetrating trauma in this early phase of primary assessment. This global standard, representative of current practice, contradicts the rejection of routine suspicion of spinal injury and cervical collars as well as the distinction between blunt and penetrating trauma by Stanton et al. (2017:4-8).

6.4.2 Published Literature

Synthesised results from this systematic review correspond with the notion that there may be value in abandoning the cervical collar as an immobilisation device. Impaired pulmonary function (Akkuş et al., 2016:1962; Ala et al., 2016:659; Işik et al., 2019:1959), compromised airway management (Holla, 2012:106; Velopulos et al., 2018:739), pain (Bruijns et al., 2013:212; Çorbacioğlu et al., 2016:66; Ham et al., 2016:1928; Swartz et al., 2018:633) and an increased intracranial pressure (ICP) (Özdoğan et al., 2019:2-3) are complications from the collar detected by the review. In addition to contributing to the development of pressure ulcers (Ham et al., 2016:1928, 2017:1139), cervical collars led to indentation marks in trauma patients.

The marks were a direct consequence of the collar, as the precise pattern was mirrored in skin indentation and redness (Ham et al., 2016:1927). Research testing the efficacy of the device found insufficient evidence to support its use as well as no clinically significant reduction in cervical motion when a cervical collar was added to head blocks (Holla, 2012:106). A consideration of the harms, coupled with the lack of supporting evidence, calls into question the value that the cervical collar has in the clinical environment.

Otier et al. (2015:529-535) systematically reviewed literature to clarify if the application of a cervical collar on adult trauma patients in the pre-hospital environment improves patient outcome. Results were not combined due to significant heterogeneity of included studies. Nonetheless, findings listed correspond with those in the present review. Pain, suprascapular lesions, increased ICP, and longer ICU stays are highlighted as consequences of immobilisation with a cervical collar. Moreover, the collar was not found to prevent progression of injury when tested in multiple studies, with one included article suggesting spinal immobilisation may correlate to worsening neurological injury in blunt trauma. Concluding remarks describe cervical spine immobilisation as a debatable topic, given the low quality of evidence available.

Concerning penetrating trauma, an unadjusted association between spinal immobilisation and increased mortality is reported in two studies included in the review by Otier et al. Concealment of neck injuries and longer scene times are offered as factors that may contribute to this augmented risk (Oteir et al., 2015:531-532). These findings resemble results from included studies by Turnock et al. (2016:4) and Velopulos et al. (2018:740) that found secondary neurological injury and mortality was significantly higher among penetrating trauma patients subjected to spinal immobilisation.

In a similar enquiry, Hood and Considine (2015:119-134) questioned whether spinal immobilisation in the pre-hospital phase affects the patient outcome, but included head blocks, long backboards and manual in-line stabilisation in the intervention. A vote count of 47 included studies revealed 15 were supportive of spinal immobilisation, 13 were neutral, and 19 studies opposed the intervention. Much like

the results of this review, respiratory complications, increased ICP, increased tissue interface pressure, skin ulceration, and dysphagia are adverse effects detected by an analysis of results. Pain and discomfort from spinal immobilisation are emphasised, as all studies exploring these factors were in complete agreement. Eight included studies investigated the relationship between spinal immobilisation and neurological outcome, with one study opposing the practice based on an association with increased mortality and the other seven studies were neutral. However, the authors do raise the issue of questionable quality in all eight studies. The review is concluded with a statement regarding the lack of high-quality research supporting the necessity and efficacy of the intervention as well as the revelatory evidence of harm. A risk versus benefit assessment by pre-hospital practitioners considering spinal immobilisation is strongly recommended.

An earlier systematic review (Ahn, Singh, Nathens, Macdonald, Travers, Tallon et al., 2011:1341-1361) sought to answer a series of questions related to the pre-hospital management of trauma patients with a suspected spinal injury. The findings from 47 included articles were circulated among several experts and recommendations were constructed using the Delphi technique.

Comparable to other systematic reviews exploring this concept, much of the research in the review by Ahn et al. (2011:1342), as well as the review at hand, was conducted on healthy volunteers. Enquiry into the most suitable method of immobilisation demonstrated the combination of the cervical collar, head blocks and long backboard provided the most restriction of spinal motion. Occipital and sacral discomfort, as well as tissue necrosis, was attributed to pressure from the hard surface of the long backboard. The review also revealed that intubation was more difficult in the presence of spinal immobilisation devices. Other facets of management focused on the effect that mode of transport and time spent on scene has on patient outcome. Lastly, the role of the paramedic in ‘clearing’ the spine is explored.

Based on expert consensus regarding the findings of the review, recommendations are provided. A cervical collar, head blocks and padded backboard are recommended to immobilise the spine. However, advice highlights the removal of the

long backboard as soon as the patient arrives at hospital. Manual in-line stabilisation and cervical spine traction are recommended for patients who require intubation. Although some parallels exist between these findings and those of the current review, there are also some points of dispute. In particular, the evidence and recommendation that traditional spinal immobilisation provides the most effective stabilisation. Notably, the date range of studies from which this evidence comes is 1987 to 2007. An analysis of recent literature implies that the addition of a long backboard and cervical collar to head blocks causes more harm than benefit (Holla, 2012:106).

Various other published guidelines may contribute to the reflection on how the results of this review correlate with existing theory. The Norwegian guidelines for the pre-hospital management of patients with a potential spine injury (Kornhall et al., 2017:1-11) discuss 10 recommendations based on the results of a systematic review of literature on the topic. Strong recommendations advise spinal stabilisation and minimal handling be implemented for blunt trauma patients. The decision to stabilise the spine should be based on clinical findings, compliant with a reliable triage tool, rather than on mechanism of injury. Moreover, spinal stabilisation is not recommended for isolated penetrating injury. Conditional recommendations advocate spinal stabilisation be accomplished using manual in-line stabilisation, head blocks, a cervical collar or a combination thereof. This recommendation comes from conflicting literature reviewed that claimed the cervical collar was both effective in reducing motion as well as harmful in terms of side effects. A scoop stretcher is advised for transfer because evidence demonstrates it is effective in stabilising the spine and produces little harm. Finally, the guideline supports transport on a vacuum mattress or ambulance stretcher and self-extrication from a wreck, where appropriate. All the evidence on which these guidelines are based was rated as either moderate or very low.

The United Kingdom's National Institute for Health and Care Excellence (NICE) published an evidence-based guideline on the emergency management of suspected or confirmed spinal injury due to trauma (NICE, 2016:NG41). An initial primary assessment involves a systematic approach like ATLS®, with manual in-line cervical spine immobilisation prioritised as the first step along with airway

assessment. Practitioners are then advised to cautiously protect the cervical spine and avoid any movement in the rest of the spine while carrying out an intentional assessment. This assessment focuses on the identification of signs and symptoms consistent with spinal injuries, such as spinal pain or localised weakness. The CCR is suggested as a decision tool, and spinal immobilisation is indicated based on its criteria as well as the presence or absence of specified signs or symptoms. The proposed method of spinal immobilisation includes a combination of a cervical collar and head blocks in the supine position, while a scoop stretcher is recommended for transfer. This guidance comes with listed contra-indications for the cervical collar as well as a suggestion to modify immobilisation techniques to accommodate unique circumstances. For example, allowing an agitated and confused patient to adopt a position of comfort is preferable. This proposal is supported with the logic that forcing such a person into an unnatural and uncomfortable position of immobilisation will provoke greater spinal motion as the patient struggles to relieve discomfort.

6.4.3 Correlation of Evidence

Despite elements of contradiction in the literature relating to the emergency management of suspected spinal injury, there is congruity regarding several fundamental principles on the subject. Most authors describe a paucity in high-level evidence to corroborate the theory that restricting motion of a potentially injured spine will reduce the odds of injury progression and neurological deficit. Nonetheless, there is also insufficient evidence to validate the total abandonment of the intervention. The life-altering consequences of spinal injury provide fair motivation to keep the practice alive and spur the pursuit of knowledge. In the meantime, what is known is that the well-established approach to spinal immobilisation may not be optimal. There is an agreement in published literature that the cervical collar and the long backboard both cause significant harm (Wampler et al., 2016:1139; Ham et al., 2017:717). While there is research that ratifies the efficacy of the cervical collar (Ahn et al., 2011:1342), there is also evidence to challenge this point (Holla, 2012:106; Holla et al., 2016:2033). The long backboard, however, has been proven unfit for reducing spinal motion and appears to have resumed its exclusive role as an extrication device (Stanton et al., 2017:7).

Pain inflicted by spinal immobilisation devices is a reoccurring result in research conducted on the topic (Bruijns et al., 2013:212; Çorbacioğlu et al., 2016:66; Ham et al., 2016:1928; Swartz et al., 2018:633). The direction of effect seems to be consistent in all studies, including those conducted on healthy volunteers. Hood and Considine (2015:135) underline that pain from spinal immobilisation detected in healthy volunteers would be emphasised in a trauma patient. In addition, Ham et al. (2016:1928) explain how pain from devices renders the intervention counterproductive as patients instinctively shift to relieve the pressure causing pain and discomfort.

Another point of concurrence is the inappropriateness of spinal immobilisation in penetrating trauma. Evidence refutes the intervention in this population group, and it is therefore widely accepted that the harm outweighs any benefit that spinal immobilisation may provide (Oteir et al., 2015:535; Kornhall et al., 2017:3; Velopulos et al., 2018:739-741). Concealment of neck injuries, delayed transport to definitive care and increased failed intubations are a few consequences that may contribute to increased mortality and increased secondary injury (Turnock et al., 2016:4-6; Velopulos et al., 2018:739-741).

Lastly, selective rather than routine spinal immobilisation for blunt trauma victims is accepted (American College of Surgeons, 2018:139) and substantiated by research evidence (Ahn et al., 2011:1360; National Institute for Health and Care Excellence, 2016:NG41; Stanton et al., 2017:5). This approach is confirmed to be specific, effective and safe when strategically implemented by trained nursing personnel in the emergency department. In addition to avoiding unnecessary adverse effects, spinal immobilisation based on clinical presentation also produces time and cost-saving benefits (Fontaine et al., 2018:228-235; Stiell et al., 2018:333-340).

6.5 LIMITATIONS OF INCLUDED STUDIES

Quality appraisal of included papers based on the CASP checklist indicates four out of 19 studies were of superior quality. Two cohort studies and two systematic reviews were awarded an affirmative answer for every question. The remaining articles were of average or poor quality.

Some cohort studies lacked clarity in reporting measures taken to minimise bias as well as how confounding variables were accounted for. Two randomised controlled trials were included with relatively small sample sizes of eight and 20, respectively. Furthermore, one of these trials was unable to blind participants and investigators.

While over half of the included studies were conducted on healthy volunteers, 37% included trauma patients, of which 11% were stable trauma patients. The systematic review by Hood and Considine (2015:135) also included primary studies conducted on healthy volunteers. In discussing the issue of extrapolated data, the authors refer to the improbability that healthy volunteers will demonstrate the same physiological and biomechanical response as an injured patient. Pain, guarding, involuntary muscle spasm and anxiety are some symptoms that are likely to be inaccurate in a volunteer study. The implication is that, although results from these trials provide valuable information, much of the data used as evidence on which to base clinical decisions may lack external validity to some degree.

Eight studies focused exclusively on suspected injury in the cervical spine. The other studies either specified or alluded to a focus on the whole spine. No studies isolated the thoracic or lumbar regions as a focus. This limitation was also noted in the review by Hood and Considine (2015:135), and is possibly because cervical spine injuries are considered most common compared to other spinal regions (Connor et al., 2013:146). Included studies that did not examine the cervical spine alone, either differentiated the anatomical regions or conducted investigations related to the whole spine. While results pertaining to the cervical spine are informative and necessary, the unbalanced emphasis seems to dismiss care of suspected injury in the thoracic and lumbar spine.

Three out of 19 included studies were mutually exclusive of nursing interventions, representing only 16% of the total sample. A lack of relevant research conducted within the field of nursing was anticipated at proposal level. As such, the eligibility criteria were structured to include studies conducted in the medical and pre-hospital fields to ensure sufficient data to answer the research question. Conclusions from

studies conducted in other fields were drawn on to make recommendations regarding nursing care, and the transfer of evidence seems worth highlighting.

The log-roll is a manoeuvre frequently used by emergency nurses used to turn, move or transfer trauma patients with suspected spinal injury. No research related to the safety and efficacy of the log-roll met the inclusion criteria for this systematic review. This represents a gap in knowledge and suggests that the intervention is not evidence-based. However, this issue cannot be addressed owing to the lack of relevant evidence.

6.6 LIMITATIONS OF THE SYSTEMATIC REVIEW PROCESS

This systematic review was conducted to fulfil requirements for the attainment of a Master's degree in nursing science from the University of Johannesburg. In line with University rules and moral code, the review was conducted independently by the primary researcher under the guidance of a supervisor. Consequently, the accepted standard of enlisting a dual reviewer in database searching, screening and data extraction was not implemented. This limitation rendered the review vulnerable to bias regarding study selection. Furthermore, any errors in the process of removing duplicates, tallying results lists, and extracting data would not have been detected, thereby threatening the accuracy of results. Although the risk of bias was addressed through consultation with an external expert, it should be noted that her degree of involvement fell short of standards stipulated by authorities in review methodology.

The broad nature of the research question, and hence the inclusion criteria, generated a large sample of relevant papers necessitating an additional phase of screening and refinement. While the search might be described as comprehensive, it may also lack specificity. Moreover, the unintended obscurity of the eligibility criteria captured studies that were particularly heterogenous regarding the definition of the intervention as well as population and setting. Consequently, a meta-analysis was impossible, and a narrative synthesis of extracted data was conducted. While appropriate for variable studies, this method of analysis is more prone to bias than the statistical pooling of numerical data as it provides no indication on the weighting of individual studies.

A further consequence of the broad question was the omission of a search for grey literature. This step was excluded as the large sample was deemed sufficient to answer the research question following screening and selection of the results from the database search. The threat of publication bias introduced by this decision is acknowledged as a limitation of the study.

Twelve potentially relevant studies conducted on cadavers were excluded during the final full text screen. The exclusion was based on the questionable external validity related to surrogate outcomes. This decision was a risk of bias as the inclusion criteria allowed for cadaver studies. The eligibility criteria were established *a priori* by the novice researcher. A lack of understanding regarding both the implications of surrogate outcomes as well as review methodology probably allowed for this initial shortfall.

A date limiter was set at 2012 for the database search to ensure the inclusion of recent research. While the decision has been justified in previous chapters, the exclusion of older research is recognised as an additional source of potential bias.

6.7 RECOMMENDATIONS FOR EMERGENCY NURSING

6.7.1 Goal-Directed Nursing Care

The scientific nursing process involves four steps; namely assessment, planning, implementation, and evaluation. This systematic approach facilitates intentional, patient-specific care (Reynolds, 2017:45). As emergency nurses incorporate the process with critical thinking and clinical judgement, a unique care plan can be designed to meet the specific needs of individual trauma patients. Recommendations based on the results of this systematic review broadly cover the needs of all patients with suspected spinal injury. As such, the goals provided here are generalised to include all patients in this population group.

Nursing goals for trauma patients with suspected spinal injury include:

- Provide evidence-based nursing care
- Provide nursing care appropriate to the needs and values of individual patients
- Appropriately prioritise interventions based on clinical presentation
- Prevent the progression of a potential spinal injury
- Promote patient safety
- Promote patient comfort
- Alleviate pain, discomfort and anxiety
- Prevent pressure ulcers related to spinal immobilisation

6.7.2 Evidence-Based Nursing Interventions for Suspected Spinal Injury

The recommendations should be interpreted and implemented within the scope of practice of the registered or enrolled nurse as set out in regulation 2598 of the Nursing Act of South Africa (South African Nursing Council, 2001). As such, the proposed interventions are intended to provide a guideline for nursing care, and do not override the medical directive provided by a practitioner of higher qualification.

Recommendation	Evidence-Based Rationale
1. Patients arriving in the ED immobilised should have long backboards removed immediately.	• Long backboards do not immobilise the spine. • There is strong evidence that links the device with pain and pressure ulcers.
2. Patients with suspected spinal injury from blunt trauma should be nursed immobilised supine on an ED stretcher in head blocks only.	• There is insufficient evidence to abandon the practice of spinal immobilisation altogether. • There is insufficient evidence to validate the efficacy and safety of the cervical collar, given the side effects that the device is known to produce.
3. Victims of penetrating trauma should not be immobilised.	• There is insufficient evidence to validate the benefit of spinal immobilisation in preventing neurological injury in penetrating trauma. • Research demonstrates that the practice is

	inappropriate in penetrating trauma. • Research demonstrates that spinal immobilisation is associated with increased mortality and increased indirect injury in penetrating trauma.
4. Trauma patients in cardiac arrest should not be immobilised. **Lifesaving interventions, such as cardiopulmonary resuscitation, oxygenation and ventilation should be prioritised over spinal immobilisation.**	• Research demonstrates that spinal immobilisation in blunt traumatic cardiac arrest is associated with an increase in mortality and a decreased chance of ROSC. (Evidence from a single study)
5. Airway management should be prioritised over spinal immobilisation. **If airway adjuncts are indicated, consider removing immobilisation devices and stabilising the cervical spine with manual in-line stabilisation instead.**	• Spinal immobilisation devices decrease mouth opening and impede airway management. • Spinal immobilisation is associated with an increased rate of failed intubation attempts.
6. Vital signs of immobilised patients should be judiciously monitored, in particular, the respiratory rate.	• Spinal immobilisation may compromise pulmonary function.
7. Pain from spinal immobilisation should be regularly monitored. **Respond with pharmacological and non-pharmacological nursing interventions.**	• Spinal immobilisation causes pain, especially in the occiput, suprascapular and sacrum. • Pain is a red flag for the development of device-related pressure ulcers.
8. Regularly inspect the skin of immobilised patients. **Respond to pain, redness and inflammation by changing position and with prompt removal or replacement of immobilisation devices.**	• Spinal immobilisation causes pressure ulcers.
9. Prioritise nursing orders related to radiological investigations for immobilised patients.	• Spinal immobilisation causes pressure ulcers. • Rapid diagnosis or exclusion of injury will encourage prompt removal or replacement of temporary immobilisation devices.

10. At institutional level, consider training and equipping emergency nurses to use the CCR as a decision tool to apply or remove spinal immobilisation.	• The CCR was shown to be effective, safe and specific in identifying the appropriateness of spinal immobilisation when used by trained ED nurses. • Benefits include increased patient comfort, shorter ED admission times and a lower rate of radiological investigations.

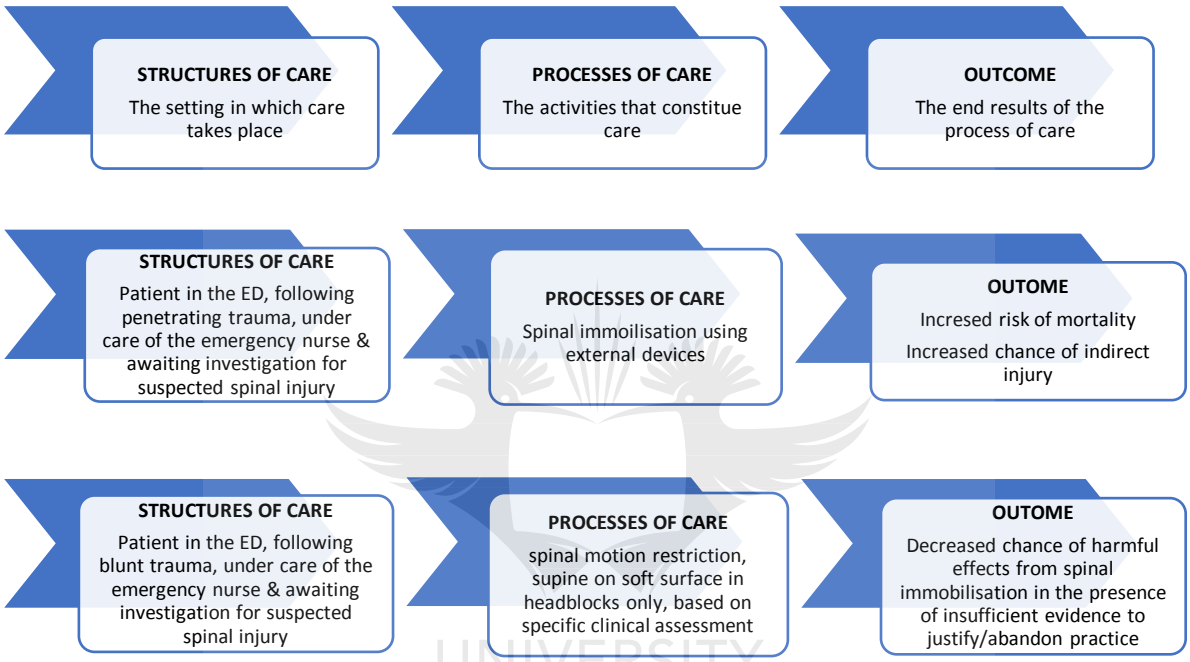


Figure 6.1 Donabedian's Structure-Process-Outcome Model (Jones, 2016:np)

6.8 RECOMMENDATIONS FOR EDUCATION

The development of critical thinking skills is an essential aspect of undergraduate nursing education. Critical thinking involves the assessment of a problem, gathering information regarding a variety of solutions, and choosing the most appropriate option. Critical thinking in nursing tailors the implementation phase of the nursing process to meet the specific needs of the patient (Potter, 2017:195). While this may involve deviating from routine care, critical thinking is embedded in the fundamental principles of evidence-based care. Consequently, the information gathered should be sourced from best research evidence and integrated with knowledge and skill. Given the global shift regarding routine spinal immobilisation, critical thinking is essential in

providing care to trauma patients with suspected spinal injury. As evidence demonstrates harm from spinal immobilisation and uncertainty regarding the real risk of progression of spinal injury, critical thinking is pertinent to provide the most appropriate care. The recommendation is that undergraduate nursing training should focus explicitly on developing this skill throughout the programme.

In addition, undergraduate nursing programmes should highlight the importance of evidence-based care, teach the practical aspects of the process, and facilitate the integration of evidence-based care with critical thinking skills. These skills will equip student nurses to question routine care and choose appropriate interventions based on patient assessment and the best research evidence.

At post-graduate level, emergency nursing programmes should teach nurses to assess the need for cervical spine immobilisation based on the CCR criteria. Evidence from this systematic review demonstrated this to be effective in mitigating adverse effects from spinal immobilisation in patients who are not at risk for a spinal injury.

A further recommendation is that nurse educators and clinical facilitators remain abreast with emerging evidence regarding caring for suspected spinal injury.

6.9 RECOMMENDATIONS FOR NURSING MANAGEMENT

As an emerging speciality in South Africa, emergency nursing lacks standardised policies and procedures (Wolf et al., 2012:175). To date, there is no generic practice guideline addressing nursing care directed at trauma patients with suspected spinal injury. Policies and procedures regarding this issue are usually provided by individual institutions, emergency units or private hospital groups. While this guidance is valuable, a generic practice guideline based on best research evidence, and distributed nationally, would be superior. It is recommended that an evidence-based practice guideline be developed and disseminated at national level, to co-ordinate standardised care that is based on best research evidence and that is safe for the patient and the nurse.

6.10 RECOMMENDATIONS FOR FURTHER RESEARCH

6.10.1 Recommendations for High-Level Evidence

An element highlighted in this systematic review, as well as other research on the topic, is the limited availability of high-level evidence on which to base decision making. Much of the research conducted on spinal immobilisation involves small sample sizes of healthy volunteers and cadavers. The randomised controlled trials included in this systematic review (Wampler et al., 2016; Swartz et al., 2018) are an example of this type of research. While cohort studies exploring the issue were retrieved, some are retrospective (Tsutsumi et al., 2018; Turnock et al., 2016) and prospective cohort studies exclude patients with multiple injuries or significant trauma (Ham et al., 2016; Ala et al., 2015).

Systematic reviews that meta-analyse statistical outcomes from high-quality experimental studies provide the strongest evidence regarding the harms and benefit of an intervention. An ample quantity of randomised controlled trials with homogenous designs, interventions, populations and measurement methods are a prerequisite for the conduct of level 1 systematic reviews and meta-analyses (Gray et al., 2017:32). While various attempts have been made at systematically reviewing evidence of spinal immobilisation (Oteir et al., 2014; Hood & Considine, 2015; Kornhall et al., 2017; Velopulos et al., 2018), these reviews consistently report a paucity of high-level experimental studies. Bridging this gap seems pertinent if there is to be any prospect at clarifying the necessity and safety of interventions related to the care and protection of a suspected spinal injury in trauma.

The obvious recommendation for further research would be large scale randomised controlled trials conducted on trauma patients. The quantitative synthesis of experimental studies would provide insight regarding the direction and magnitude of effect in the relationship between spinal immobilisation and secondary injury or neurological outcome. However, given the consequences of a spinal injury, research of this nature is likely to be difficult to conduct from both a practical and ethical standpoint. Prospective descriptive studies exploring the topic would provide a valuable alternative to randomised controlled trials. As a further recommendation, research should involve trauma patients, rather than healthy volunteers and

cadavers. Replicated designs such as these are also scant and would likely be more appropriate to implement. The conduct of multiple observational designs exploring suspected spinal injury would contribute to best research evidence by providing a body of research to systematically synthesise.

6.10.2 Recommendations for Nursing Research

Research generates a body of empirical knowledge necessary for developing a science on which to base a profession (Gray et al., 2017:2,7). This systematic review retrieved minimal research conducted within the field of nursing. While the research that has been conducted in the area of interest can be used as a source of evidence-based decision making, this is essentially borrowed knowledge as the focus is generally on the roles and responsibilities unique to pre-hospital or medical personnel. This means that the evidence available may lack information specific to the nursing profession.

The lack of research in the nursing field regarding suspected spinal injury is unsurprising as Sutherland et al. (2017:8) describe the profession as one that is in the process of developing its own science through the conduct of original and replicated research. This notion is mirrored by Wolf et al. (2012:177) who portray emergency nursing as a new addition to Africa, and therefore a speciality yet to develop its own guidelines and standards. The prospect of primary research observing the human response to nursing interventions directed at suspected spinal injury is, therefore, an exciting and necessary endeavour for nurses internationally and in South Africa.

As pain is a reoccurring effect from spinal immobilisation, quantitative observational designs might focus on the effect that non-pharmacological nursing interventions would have on this outcome. Intentional communication between nurses and immobilised patients is one example of an intervention that could be explored within this context.

In keeping with the nursing profession, the log-roll is well established as an intervention used by nurses to transfer, move or provide pressure care to immobilised patients. A literature search conducted for operational definitions retrieved a discussion (Benolken et al., 2016) and a literature review (Rowell, 2014) addressing the harms and benefits of the log-roll. However, no research regarding the log-roll congruent with the eligibility criteria for this systematic review was retrieved. Therefore, the conduct of high-level research exploring the efficacy and adverse effects of this intervention by nurses seems necessary, especially considering the aforementioned literature suggested harm.

6.11 CONCLUSION

A comprehensive and systematic search was conducted to locate primary literature applicable to the research question. The body of research produced from the search was screened based on pre-determined eligibility criteria to further identify relevant studies for inclusion in the review. Data were extracted and synthesised to determine outcomes produced from interventions directed at suspected spinal injury.

Following critical appraisal, synthesised results were correlated to other similar systematic reviews. Following this analytical interpretation, inferences were drawn, and recommendations developed.

Motivated by the ideal of rigorous research, standard methodology was followed for this systematic review. Given the scope of the review and the experience of the researcher, the question was suitably answered by adhering to accepted processes. The purpose and specific objectives of the study were fulfilled through the identification, examination and evaluation of quantitative literature. That said, there are significant limitations regarding the quality of included studies and the review process. The recommendations are therefore inadequate to be used to inform policy or change clinical practice.

The findings are offered as inductions developed from the systematically searched and synthesised literature. Although insufficient to replace current protocols, the guidance could be used to stimulate conversation and critical thinking among

emergency nurses. In addition, the recommendations provide evidence to facilitate informed decision making in balancing the benefit of nursing interventions against the harms, while considering the needs and values of the patient.

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ADDENDUM A: REC APPROVAL

UNIVERSITY OF JOHANNESBURG

FACULTY OF HEALTH SCIENCES

RESEARCH ETHICS COMMITTEE

NHREC Registration no: REC-241112-035

REC-01-133- 2017

20 November 2017

TO WHOM IT MAY CONCERN:

STUDENT: **GELDENHUYS, M**
STUDENT NUMBER: **920400812**

TITLE OF RESEARCH PROJECT: Evidenced Based Nursing Care for Spinal Immobilisation: A Systematic Review

DEPARTMENT OR PROGRAMME: NURSING

SUPERVISOR: Dr C Downing **CO-SUPERVISOR:** Prof WE Nel

The Faculty Research Ethics Committee has scrutinised your research proposal and confirm that it complies with the approved ethical standards of the Faculty of Health Sciences; University of Johannesburg.

The REC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely,

Prof C Stein
Chair : Faculty of Health Sciences REC
Tel: 011 559 6564
Email: cstein@uj.ac.za

ADDENDUM B: HDC APPROVAL

UNIVERSITY OF JOHANNESBURG

FACULTY OF HEALTH SCIENCES

HIGHER DEGREES COMMITTEE

HDC-01-80- 2017

20 November 2017

TO WHOM IT MAY CONCERN:

STUDENT: GELDENHUYS, M
STUDENT NUMBER: 920400812

TITLE OF RESEARCH PROJECT: Evidenced Based Nursing Care for Spinal Immobilisation: A Systematic Review

DEPARTMENT OR PROGRAMME: NURSING

SUPERVISOR: Dr C Downing **CO-SUPERVISOR:** Prof WE Nel

The Faculty Higher Degrees Committee has scrutinised your research proposal and concluded that it complies with the approved research standards of the Faculty of Health Sciences; University of Johannesburg.

The HDC would like to extend their best wishes to you with your postgraduate studies

Yours sincerely,

Prof BS Shaw
Chair: Faculty of Health Sciences HDC
Tel: 011 559 6891
Email: brandons@uj.ac.za

ADDENDUM C: ELIGIBILITY CRITERIA

INCLUSION CRITERIA	**EXCLUSION CRITERIA**
Reporting Characteristics	**Reporting Characteristics**
Types of Studies	***Types of Studies***
Quantitative design (experimental, quasi-experimental, observational, systematic review) All languages Publication from 2012 onwards	Qualitative design Case studies, literature reviews, opinion articles, editorials Publication before 2012
Study Characteristics	*Study Characteristics*
Population	***Population***
Adult patients (12 years and older) Suspected spinal injury (cervical, thoracic or lumbar) Due to blunt or penetrating trauma (will include healthy volunteers or cadavers)	Children (11 years or younger) Confirmed spinal injury Suspected spinal injury due to a pathology other than trauma Animal studies
Concept	***Concept***
Studies examining interventions directed at the protection, care and management of suspected spinal injury	Studies examining interventions directed at the management of confirmed spinal injury
Context	***Context***
In – hospital emergency care (emergency department) Pre-hospital and transport	Long term care (intensive care, after diagnosis and admission, rehabilitative)

(awaiting decision, acute management, prior to diagnosis, discharge, transfer)	

ADDENDUM D: FULL SEARCH STRATEGY

Search ID	Hits	Date	Database	Search String
1	0	2019/04/03	CINAHL	Emergency AND nursing AND interventions AND trauma AND suspected spinal injury
2	0	2019/04/03	CINAHL	nursing AND interventions AND trauma AND suspected spinal injury
3	2	2019/04/03	CINAHL	emergency AND interventions AND trauma AND suspected spinal injury
4	3	2019/04/03	CINAHL	interventions AND trauma AND suspected spinal injury
5	13	2019/04/03	CINAHL	trauma AND suspected spinal injury
6	4	2019/04/03	CINAHL	Interventions AND suspected spinal injury
7	2	2019/04/03	CINAHL	nursing AND suspected spinal injury
8	20	2019/04/03	CINAHL	suspected spinal injury
9	0	2019/04/03	CINAHL	emergency AND nursing AND interventions AND trauma AND spinal immobili?ation
10	1	2019/04/03	CINAHL	emergency AND interventions AND trauma AND spinal immobili?ation
11	0	2019/04/03	CINAHL	nursing AND interventions AND trauma AND Spinal immobili?ation
12	2	2019/04/03	CINAHL	interventions AND trauma AND spinal immobili?ation
13	45	2019/04/03	CINAHL	trauma AND spinal immobili?ation
14	99	2019/04/03	CINAHL	spinal Immobili?ation
15	12	2019/04/03	CINAHL	spinal motion restriction
16	7	2019/04/03	CINAHL	'possible spine injury'
17	94	2019/04/03	CINAHL	spinal cord injuries prevention and control
18	103	2019/04/03	CINAHL	spine immobili?ation
19	20	2019/04/03	CINAHL	spine motion AND trauma
20	0	2019/04/04	MEDLINE	emergency AND nurs*AND interventions AND trauma AND suspected spin* injury
21	0	2019/04/04	MEDLINE	nurs* AND interventions AND trauma AND suspected spin* injury
22	4	2019/04/04	MEDLINE	emergency AND interventions AND trauma AND suspected spin* injury
23	7	2019/04/04	MEDLINE	interventions AND trauma AND suspected spin* injury
24	9	2019/04/04	MEDLINE	interventions AND suspected spine* injury
25	55	2019/04/04	MEDLINE	trauma AND suspected spin* injury
26	6	2019/04/04	MEDLINE	nurs* AND suspected spin* injury
27	80	2019/04/04	MEDLINE	suspected spin* injury
28	3	2019/04/04	MEDLINE	emergency AND nurs* And interventions AND Trauma AND spin* immobili?ation
29	7	2019/04/04	MEDLINE	emergency AND interventions AND trauma AND spin* immobili?ation
30	2	2019/04/04	MEDLINE	nurs* AND interventions AND trauma AND spin* immobili?ation
31	10	2019/04/04	MEDLINE	interventions AND trauma AND spin* immobili?ation
32	136	2019/04/04	MEDLINE	trauma AND spin* immobili?ation
33	310	2019/04/04	MEDLINE	spin* immobili?ation
34	95	2019/04/04	MEDLINE	possible spin* injury
35	26	2019/04/04	MEDLINE	spin* motion restriction
36	33	2019/04/04	MEDLINE	spinal cord injuries prevention and control
37	91	2019/04/04	MEDLINE	spin* motion AND trauma
38	142	2019/04/04	MEDLINE	emergency AND nurs* AND spin*
39	130	2019/04/05	Academic Search Ulitmate	emergency AND nurs* AND spin*(RAN SEARCH TWICE – CORRECTED ON MENDELEY)
40	1	2019/04/06	Academic Search Ultimate	emergency AND nurs* AND interventions AND trauma AND suspected spin* injury
41	1	2019/04/06	Academic Search Ultimate	nurs* AND interventions AND trauma AND suspected spin* injury
42	2	2019/04/06	Academic Search Ultimate	emergency AND interventions AND trauma AND suspected spin* injury
43	4	2019/04/06	Academic Search Ultimate	interventions AND trauma AND suspected spin* injury
44	4	2019/04/06	Academic Search Ultimate	interventions AND suspected spin* injury
45	6	2019/04/06	Academic Search Ultimate	interventions AND suspecetd spin* injury
46	29	2019/04/06	Academic Search Ultimate	trauma AND suspected spin* Injury
47	40	2019/04/06	Academic Search Ultimate	suspected spin* Injury
48	3	2019/04/06	Academic Search Ultimate	nurs* AND suspected spin* injury
49	2	2019/04/06	Academic Search Ultimate	emeregcny AND interventions AND nurs* AND trauma AND spin* immobili?astion
50	7	2019/04/06	Academic Search Ultimate	emergency AND interventions AND trauma AND spin* immobili?ation
51	2	2019/04/06	Academic Search Ultimate	nurs* AND interventions AND trauma spin* immobili?ation
52	9	2019/04/06	Academic Search Ultimate	interventions AND trauma AND spin* immobili?ation
53	68	2019/04/06	Academic Search Ultimate	trauma AND spin* immobili?ation
54	168	2019/04/06	Academic Search Ultimate	spin* immobili?ation
55	11	2019/04/06	Academic Search Ultimate	spin* motion restriction
56	16	2019/04/06	Academic Search Ultimate	spinal cord injuries prevention and control

57	64	2019/04/06	Academic Search Ultimate	spin* motion AND trauma
58	130	2019/04/06	Academic Search Ultimate	emergency AND nurs* AND spine*
59	50	2019/04/06	Academic Search Ultimate	possible spin* injury
60	17	2019/04/06	Science Direct	emergency AND (nurse OR nurses OR nursing) AND interventions AND trauma AND "suspected spinal injury"
61	18	2019/04/06	Science Direct	(nurse OR nurses OR nursing) AND interventions AND trauma AND "suspected spinal injury"
62	26	2019/04/06	Science Direct	emergency AND interventions AND trauma AND "suspected spinal injury"
63	31	2019/04/06	Science Direct	interventions AND trauma AND "suspected spinal injury"
64	49	2019/04/06	Science Direct	Trauma AND "suspected spinal injury"
65	31	2019/04/06	Science Direct	interventions AND "suspected spinal injury"
66	52	2019/04/06	Science Direct	"suspected spinal injuy"
67	18	2019/04/06	Science Direct	"suspected spine injury"
68	6	2019/04/06	Science Direct	"possible spine injury"
69	24	2019/04/06	Science Direct	(nurse OR nurses OR nursing) AND "suspected spinal injury"
70	50	2019/04/06	Science Direct	emergency AND (nurse OR nurses OR nursing) AND interventions AND trauma AND "spinal immobilization"
71	50	2019/04/06	Science Direct	(nurse OR nurses OR nursing) AND interventions AND trauma AND "spinal immobilization"
72	108	2019/04/06	Science Direct	emergency AND interventions AND trauma AND "spinal immobilization"
73	118	2019/04/06	Science Direct	interventions AND trauma AND "spinal immobilization"
74	184	2019/04/06	Science Direct	trauma AND "spinal immobilization"
75	209	2019/04/06	Science Direct	"spinal immobilization"
76	53	2019/04/06	Science Direct	"spinal immobilisation"
77	26	2019/04/06	Science Direct	"spinal motion restriction"
78	7	2019/04/06	Science Direct	"spine motion restriction"
79	0	2019/04/06	36 supplement 2	"spinal cord injuries prevention and control"
80	47	2019/04/06	Science Direct	"spine immobilsation
81	303	2019/04/06	Science Direct	"spine immobilization"
82	0	2019/04/06	SAGE	emergency AND nurs* AND interventions AND trauma AND "suspected spinal injury"
83	0	2019/04/06	SAGE	nurs* AND interventions AND trauma AND "suspected spinal injury"
84	0	2019/04/06	SAGE	emergency AND interventions AND trauma AND "suspected spinal injury"
85	0	2019/04/06	SAGE	interventions AND trauma AND "suspected spinal injury"
86	2	2019/04/06	SAGE	trauma AND "suspected spinal injury"
87	0	2019/04/06	SAGE	interventions AND "suspected spinal Injury"
88	3	2019/04/06	SAGE	"suspected spinal injury"

89	0	2019/04/06	SAGE	nurs* AND "suspected spinal injury"
90	1	2019/04/06	SAGE	"possible spinal injury"
91	124	2019/04/06	SAGE	suspected AND "spinal injury"
92	0	2019/04/06	SAGE	"spinal motion restriction"
93	12	2019/04/06	SAGE	"motion restriction" AND spine
94	15	2019/04/06	SAGE	"spine motion" AND trauma
95	94	2019/04/06	SAGE	emergency AND nurs* AND spin* (spin* in title)
96	4	2019/04/06	SAGE	emergency AND nurs* AND interventions AND trauma AND "spinal immobilization"
97	13	2019/04/06	SAGE	emergency AND interventions AND trauma AND "spinal immobilization"
98	6	2019/04/06	SAGE	nurs* AND interventions AND trauma AND "spinal immobilization"
99	17	2019/04/06	SAGE	interventions AND trauma AND "spinal immobilization"
100	29	2019/04/06	SAGE	trauma AND "spinal immobilization"
101	30	2019/04/06	SAGE	"spinal immobilization"
102	30	2019/04/06	SAGE	"spinal immobilisation"
103	41	2019/04/06	SAGE	"spine immobilization"
104	41	2019/04/06	SAGE	"spine immobilisation"
105	12	2019/04/06	Sabinet	emergency AND nurs* AND interventions AND trauma AND suspected spinal injury
106	15	2019/04/06	Sabinet	nurs* AND interventions AND trauma AND suspected spinal injury
107	26	2019/04/06	Sabinet	emergency AND interventions AND trauma AND suspected spinal injury
108	36	2019/04/06	Sabinet	interventions AND trauma AND suspected spinal injury
109	67	2019/04/06	Sabinet	interventions AND trauma
110	52	2019/04/06	Sabinet	trauma AND suspected spinal injury
111	107	2019/04/06	Sabinet	suspected spinal injury
112	54	2019/04/06	Sabinet	"spinal injury" AND (possible OR potnetial)
113	4	2019/04/06	Sabinet	emergency AND nurs* AND interventions AND trauma AND spinal immobilisation
114	9	2019/04/06	Sabinet	emergency AND interventions AND trauma AND spinal immobilisation
115	7	2019/04/06	Sabinet	nurs* AND interventions AND trauma AND spinal immobilisation
116	14	2019/04/06	Sabinet	interventions AND trauma AND spinal immobilisation
117	28	2019/04/06	Sabinet	trauma AND spinal immobilisation
118	52	2019/04/06	Sabinet	spinal immobilisation
119	52	2019/04/06	Sabinet	spinal immobilization
120	51	2019/04/06	Sabinet	spine immobilisation
121	51	2019/04/06	Sabinet	spine immobilization
122	45	2019/04/06	Sabinet	spinal motion restriction
123	44	2019/04/06	Sabinet	spine motion AND trauma
124	92	2019/04/06	CINAHL	emergency AND nurs* AND spin*

ADDENDUM E: EXAMPLE OF CITATION MANAGEMENT FOLLOWING ABSTRACT SCREEN

This is an example of some of the information that was populated. Due to space constraints, not all of the detail is displayed

Study ID	Search ID	Study Title	Authors
s1	8	The characteristics and pre-hospital management of bunt trauma patients with suspected spinal column injuries: a retrospective observational study.	Oosterworld et al
s10	8	Effect of training in advanced trauma life support on the kinematics of the spine: A simulation study.	Gordillo et al
s101	19	Total motion generated in the unstable thoracolumbar spine during management of the typical trauma patient: a comparisons method in a cadaver model.	Prasarn et al
s102	19	The effect of cervical orthoses on swallowing physiology and the cervical spine motion during swallowing.	Mekata et al
s103	19	Motion produced in the unstable cervical spine by the HAINES and lateral recovery positions.	Del Rossi et al
s104	19	Motion generated in the unstable cervical spine during the application and removal of cervical immobilization collars	Prasarn et al
s107	27	Comparing the Efficacy of Methods for Immobilizing the Cervical Spine	Rahmatalla et al
s108	27	Cervical collars and immobilisation: A South African best practice recommendation.	Stanton et al
s109	27	Comparing the Efficacy of Methods for Immobilizing the Thoracic-Lumbar Spine.	Rahmatalla et al
s11	8	The definite risks and questionable benefits of liberal pre-hospital spinal immobilisation	Purvis et al
s113	27	Horizontal Slide Creates Less Cervical Motion When Centering an Injured Patient on a Spine Board.	DuBosse et al
s114	27	Cervical spine immobilization in the elderly population.	Rao et al
s117	27	EMS spinal precautions and the use of the long backboard - resource document to the position statement of the National Association of EMS Physicians and the American College of Surgeons Committee on Trauma.	White et al
s118	27	Motion generated in the unstable upper cervical spine during head-tilt lift and jaw thrust maneuvers.	Prasarn et al

Study ID	Search ID	Study Title	Authors
s120	33	Effects of Spinal Immobilization and Spinal Motion Restriction on head-Neck Kinematics during Ambulance Transport	Thezard et al
s121	33	The effects of spinal immobilization at 20 degrees on intracranial pressure	Ozdogan
s123	33	Development of a new Emergency Medicine Spinal Immobilization Protocol for trauma patients and a test of applicability by German emergency care providers.	Kreinest et al
s124	33	Cervical spine immobilization may be of value following firearm injury to the head and neck.	Schuble
s131	33	Prehospital spinal immobilization after trauma	Theodore et al
s132	33	Cervical Spine Alignment in Helmeted Skiers and Snowboarders with Suspected Head and Neck Injuries: Comparison of Lateral C-spine Radiographs Before and After Helmet Removal and Implications for Ski Patrol Transport	Murray et al
s137	33	Comparison of three prehospital cervical spine protocols for missed injuries	Hong et al
s139	33	Is sub-occipital padding necessary to maintain optimal alignment of the unstable spine in the prehospital setting? A preliminary report	Del Rossi et al
s14	8	A numerical study to analyse the risk for pressure ulcer development on a spine board.	Oomens et al
s140	33	Glass Intact Assures Safe Cervical Spine Protocol	Sochor et al
s143	33	Prehospital use of cervical collars in trauma patients: a critical review.	Sundstorm et al
s144	35	Validation of a field spinal motion restriction protocol in a level 1 trauma centre	Tatum et al
s146	35	The long spine board does not reduce lateral motion during transport - a randomized healthy volunteer crossover trial	Wampler et al
s148	37	Motion and dura sac compression in the upper cervical spine during the application of a cervical collar in the case of an unstable craniocervical junction - A study in two new cadaveric trauma models	Liao et al
s151	38	Cervical Spine Collar Removal by Emergency Room Nurses: A quality improvement project	Fontaine et al
s152	38	Can emergency nurses safely and accurately remove cervical spine collars in low risk adult trauma patients: An integrative review	Smith et al
s155	38	Biomechanical analysis of the cervical spine movement on removal of motorcycle helmets	Gordillo

ADDENDUM F: REASONS FOR EXCLUSION AFTER FINAL FULL TEXT SCREEN

EXCLUDED STUDIES

1. STUDY ID

Oosterworld s1

REASON FOR EXCLUSION

"This retrospective observational study described the characteristics and pre-hospital management of patients who received spinal immobilisation by EMS staff."

This article describes various interesting characteristics surrounding the types of patients that receive immobilisation, the reasons why EMS choose to immobilise, the type of immobilisation use, the time intervals and the type of analgesia administered. However, the only direct outcome reported are the adverse effects of spinal immobilisation, such as pain, nausea and shortness of breath etc. There is no part of this study that will answer the question as to how nurses can effectively manage a suspected spinal injury.

Therefore, the article does not directly address the central issue and will likely not answer the research question.

2. STUDY ID

Hemmes s29

REASON FOR EXCLUSION

"*In this comparative study, 30 anaesthetized patients were randomized to immobilization on either the rigid spineboard or the soft-layered spineboard for the duration of their elective surgery*."

The concept in this study is certainly relevant to the research question of the systematic review. Eligibility criteria do include healthy volunteers and cadavers, so this study could be broadly grouped under that criteria, albeit a grey area. However, another grey area is the setting of this study, that being elective surgery. Too much uncertainty and therefore deemed irrelevant based on these two aspects.

3. STUDY ID

Hong s137

REASON FOR EXCLUSION

"The primary outcome measure was to determine the proportion of patients who would require cervical immobilization based on each protocol. The secondary outcome measure was to determine the number of missed cervical spine injuries given 100% compliance, which may validate the use of these protocols in the prehospital setting based on the number of missed injuries and number of unnecessary cervical immobilizations without any benefit to injured patients."

The objective of this study appears to determine the sensitivity of three different spinal immobilization protocols as well as compare this aspect of the protocols to each other. The does not meet the 'concept' inclusion criteria because it does not examine patient directed interventions, but rather the guidelines that direct the decision to implement the intervention.

"*Patients were included in this cohort if they were 18 years or older and experienced a blunt trauma that was not isolated to an extremity (e.g. crush injury to the forearm or isolated ankle sprain would be excluded). Patients that met our internal Trauma Alert activation criteria (Appendix) were immediately evaluated by the Trauma Team and were excluded from the study. We excluded these patients because insufficient immobilization of these referred patients was not a concern. All patients deemed to require a trauma evaluation were automatically placed in immobilization by the prehospital providers, so noncompliance with the PHTLS protocol did not occur. Instead, we wished to assess compliance with cervical spine immobilization criteria in a more varied population where compliance was already a concern, namely patients who presented to the ED."*

The most severe cases of trauma were excluded from the study because they would have received spinal immobilisation anyway. This seems to reiterate that the researchers were not interested in the outcome of spinal immobilisation itself (an intervention directed at the protection of suspected spinal injury), but rather sought to establish efficacy of a tool to assist in the decision to immobilise a patient who is not an obvious candidate for immobilisation.

4. STUDY ID

Todd s57

REASON FOR EXCLUSION

"We have reviewed the reports we have provided for the Court on patients with traumatic SCI, in order to determine the frequency and causes of neurological deterioration in these patients."

The population in this study include patients with confirmed spinal cord injury. It would meet inclusion criteria if it explored the interventions implemented before that diagnosis was made, but the article is unclear on this point.

"Age, gender, level of skeletal injury, nature of the injury, Frankel grade23 on first assessment, whether neurological deterioration had occurred, if there was any neurological deterioration, the Frankel grade after deterioration and the probable cause of neurological deterioration were recorded."

"The consensus opinion of the authors, based on our interpretation of the medical records and the chronological developments, is that all 23 patients deteriorated because of excessive movement at the level of the unstable fracture and/or dislocation."

Records were examined to compare the degree of neurological fall out before and after deterioration, and it was established that the majority of patients deteriorated due to excessive movement. However, it is unclear as to how this conclusion was reached.

"Neurological deterioration occurred intraoperatively in one patient;"

It appears that interventions examined are not exclusively prior to imaging and diagnosis.

5. STUDY ID

Mahshidfar s60

REASON FOR EXCLUSION

"This study was done to compare spinal immobilization using LBB with VMS in trauma victims transported by Emergency Medical Service in Tehran, Iran."

This study meets eligibility criteria in all categories. However, a vacuum mattress splint is used to immobilise a trauma patient requiring transport by road or air. The device is rarely used in an emergency department as it limits access to the patient. Although eligible, the relevance of the results for nurses working in a South African emergency department are therefore questionable.

6. STUDY ID

Mok s84

REASON FOR EXCLUSION

"*This retrospective cohort analysis compared the initial 60 patients transported by the VSB (the VSB group) with 30 patients with unstable spinal fractures transported before adoption of the VSB (the non-VSB group).*"

This study meets eligibility criteria in all categories. However, a vacuum mattress splint is used to immobilise a trauma patient requiring transport by road or air. The device is rarely used in an emergency department as it limits access to the patient. Although eligible, the relevance of the results for nurses working in a South African emergency department are therefore questionable.

7. STUDY ID

Gordillo s10

REASON FOR EXCLUSION

"In this study, we aimed to analyse the effect of training in advanced trauma life support (ATLS) on the kinematics of the spine when performing different mobilization and immobilization techniques on patients with suspected SCI"

The intervention in this study involves training nurses in the ATLS program. Although this has an impact on the way in which nurses immobilise and mobilise patients, it is not a direct patient intervention. This systematic review seeks to explore interventions that nurses can implement in the emergency department to protect and manage a suspected spinal injury.

8. STUDY ID

Rahmatalla s107

REASON FOR EXCLUSION

"A motion platform reproduced shocks and vibrations from ambulance and helicopter field rides, as well as more severe shocks and vibrations that might be encountered on rougher terrain and in inclement weather (designated as an "augmented" ride)."

This study does meet all the inclusion criteria, which did specify that studies conducted in the pre-hospital environment would be included. However, the objective of the study seeks to compare the efficacy of methods of spinal immobilization in the context of a moving vehicle. Therefore, although eligible, the results of the study are not likely to be relevant to nurses caring for trauma patients in the emergency department.

9. STUDY ID

Rahmatalla s109

REASON FOR EXCLUSION

"A dynamic simulation system was used to reproduce transport-related shocks and vibration, and involuntary movements of the thoracic-lumbar region were measured using 3 immobilization configurations."

This study does meet all the inclusion criteria, which did specify that studies conducted in the pre-hospital environment would be included. However, the objective of the study seeks to compare the efficacy of methods of spinal immobilization in the context of a moving vehicle. Therefore, although eligible, the results of the study are not likely to be relevant to nurses caring for trauma patients in the emergency department.

10. STUDY ID

Thezard s120

REASON FOR EXCLUSION

"This is a balanced-order, repeated measures comparison of two spinal precaution conditions on head-neck kinematics during a series of ambulance driving tasks"

This study does meet all the inclusion criteria, which did specify that studies conducted in the pre-hospital environment would be included. However, the objective of the study seeks to determine the influence of ambulance motion on head and neck kinematics as well as compare efficacy of spinal precaution protocols. Therefore, although eligible, the results of the study are not likely to be relevant to nurses caring for trauma patients in the emergency department.

11. STUDY ID

Decoster s169

REASON FOR EXCLUSION

"Recommendations from the 2009 National Athletic Trainers' Association position statement on the management of acute cervical spine injuries state that if the helmet is removed, the shoulder pads should also be removed. The process of moving a spine-injured athlete to remove the shoulder pads may create undesired motion of the head or the cervical spine, increasing the risk of iatrogenic injury."

"Therefore, the purpose of this study was to determine whether the placement of padding beneath the occiput after helmet removal is an effective intervention to maintain neutral sagittal cervical spine alignment in a position comparable with leaving the helmet in place."

This study does meet all the inclusion criteria, which did specify that studies conducted in the pre-hospital environment would be included. Although the concept of this study is congruent with that of the systematic review, the context appears to be specific to on field management of American Football players with suspected spinal injury. The helmet and large shoulder pads worn by these athletes are unique to the game. Although similar to other sports, such as ice hockey, the generalisability of the results of the study are questionable to the South African emergency department as these are sports, and therefore sport equipment, rarely dealt with in this context.

12. STUDY ID

Pernik s181

REASON FOR EXCLUSION

"*The purpose of this investigation was to compare the tissue interface pressures between the SB and VMS in the occiput, scapulae, sacrum, and heels of healthy subjects lying on each device"*

This study meets eligibility criteria in all categories. However, a vacuum mattress splint is used to immobilise a trauma patient requiring transport by road or air. The device is rarely used in an emergency department as it limits access to the patient. Although eligible, the relevance of the results for nurses working in a South African emergency department are therefore questionable.

13. STUDY ID

Murray s132

REASON FOR EXCLUSION

"The purpose of the current study was to observe changes in cervical spine alignment after the addition of a cervical collar to a helmeted skier, and after helmet removal and c-collar application in the mock-injured athlete stabilized on a spinal backboard by obtaining lateral c-spine radiographs in 3 common scenarios: 1) helmet on, without a cervical collar; 2) helmet on, with a cervical collar; and 3) helmet removed, with a cervical collar."

The study does meet the eligibly criteria. Although eligibility included studies conducted in the prehospital environment, the objective of this study is explicitly that of helmeted skiers. This is not a scenario likely to be managed in a South African emergency department and therefore the results may not be generalisable, and the study was therefore excluded.

14. STUDY ID

Etier s82

REASON FOR EXCLUSION

"the current study aimed to compare cervical spine motion between a traditional rigid spine board and a full-body vacuum splint."

"the secondary aim of this study was to investigate the influence of football equipment, and the process of equipment removal, on cervical spine motion using each immobilization type."

The study does meet eligibility criteria. However, it is excluded as the results may not be generalizable to the present systematic review and it is therefore likely that this article will not contribute to answering the research question. Relevance is questionable because a vacuum splint is designed for the immobilization of suspected spinal injury during transport by land or air. The device is rarely used in the emergency department as it limits access to the patient. Furthermore, the study explicitly examines the influence of football equipment (and the removal thereof) on spine motion. Football equipment is unique to this sport and a similar scenario is unlikely in a South African emergency department.

15. STUDY ID

Purvis s11

REASON FOR EXCLUSION

"This critical review aims to determine whether the side effects of pre-hospital spinal immobilisation outweigh the potential benefits."

This was initially thought to be a systematic review. Upon further scrutiny, it is a critical literature review and therefore does not meet the inclusion criteria.

16. STUDY ID

Smith s152

REASON FOR EXCLUSION

"An integrative review was conducted."

This was initially thought to be a systematic review. Upon further scrutiny, it is an integrative review and therefore does not meet the inclusion criteria.

17. STUDY ID

Prasarn s204

REASON FOR EXCLUSION

"To our knowledge, there has been no published study that investigates the effectiveness of different spineboarding techniques in the football player in uniform with an unstable cervical spine. We sought to evaluate spinal motion generated during 3 spine-board transfer techniques in a cadaveric model with an unstable cervical spine injury and with the model wearing shoulder pads and a helmet. The null hypothesis was that there would be no difference between these 3 techniques."

This study does meet all the inclusion criteria. Although the concept of this study is congruent with that of the systematic review, the context appears to be specific to on field management of American Football players with suspected spinal injury. The helmet and large shoulder pads worn by these athletes are unique to the game. Although similar to other sports, such as ice hockey, the generalisability of the results of the study are questionable to the South African emergency department as these are sports, and therefore sport equipment, rarely dealt with in this context.

18. STUDY ID

Prasarn s79

REASON FOR EXCLUSION

"The purpose of this study was to compare the rigid spine board versus the vacuum mattress splint with regards to the ability to immobilize an unstable sub axial cervical spine injury."

The study does meet eligibility criteria. However, it is excluded as the results may not be generalizable to the present systematic review and it is therefore likely that this article will not contribute to answering the research question. Relevance is questionable because a vacuum splint is designed for the immobilization of suspected spinal injury during transport by land or air. The device is rarely used in the emergency department as it limits access to the patient.

19. And 20. STUDY ID

Ham s12 and Ham s2

REASON FOR EXCLUSION

Ham s12

"In this study, we describe the incidence and characteristics of PUs, and the proportion of PUs that are related to devices, in adult trauma patients with suspected spinal injuries admitted to the hospital for the treatment of acute traumatic injuries."

"Between January and December 2013, a prospective observational cohort study was conducted in a trauma centre in the Netherlands"

"Finally, 290 patients were recruited for the study, and 36 patients were lost to follow-up. Ultimately, 254 trauma patients were included for analysis"

Ham s2

"The aim of this study was to explore the influence of risk factors present at ED admission on PU development in trauma patients with suspected spinal injury, admitted to the hospital for evaluation and treatment of acute traumatic injuries."

"Between January and December 2013, we conducted a prospective cohort study in a level one trauma center in The Netherlands"

"Finally, 290 patients were recruited for the study. 36 patients were lost to follow up during the study. Ultimately, 254 trauma patients were included for analysis"

Ham s12, Ham s2 and Ham s74 appear to be three different articles written from the same study. All three articles discuss the relationship between pressure ulcers and spinal immobilisation applied for suspected spinal injury. S12 focuses explicitly on device-related pressure ulcers and includes pressure ulcers from devices after definitive care has been commenced. For example, pressure ulcers from endotracheal tubes, feeding tubes etc. s2 focuses explicitly on the influence of other risk factors in the emergency department. S74 focuses explicitly on pressure ulcers from cervical collars and head blocks. All three articles are based on the same participants from the same sample. Therefore, including all three articles would be to triplicate data and would introduce bias into the systematic review. S12 and s2 will be excluded because the concept discussed in s74 appears to be most congruent with that of the study at hand.

21. STUDY ID

Oomens s14

REASON FOR EXCLUSION

"Although existing guidelines advise the time spent on the spine board to be kept to a minimum (Brownlee, 2005; Vickery, 2001), in practice, patients remain on the board for prolonged periods, due to the on-scene treatment and evaluation in the emergency room and/or the radiological facility (Cooke, 1998; Stagg and Lovell, 2008)"

"Although stabilisation of the spine remains a critical requirement for trauma patients, it is also clear that prolonged immobilisation on the spine board causes pain and discomfort (Cordell et al., 1995; Hauswald et al., 2000; Zlupko et al., 2004) and, on occasions, may lead to the development of pressure ulcers (Baldwin and Ziegler, 1998; Cordell et al., 1995; Watts et al., 1998)."

"In the current paper the values of mechanical strains will be estimated in sacral tissues of subjects supported on a spine board. Two different support surfaces will be considered, namely, a standard long spine board and a prototype spine board with a soft-covered inlay, the soft-layered long spine board"

"Two specific questions will be addressed: 1. Has the deformation threshold exceeded in the sacral area of subjects lying in supine position on a spine board? 2. Is the prototype soft-layered long spine board capable of reducing the internal strains to values below the deformation damage threshold?"

It is already known that a relatively short time spent on a spine board will results in tissue damage/pressure ulcers. It is also already known that a soft surface causes less tissue damage than a hard one. This study adds value by quantifying the mechanical shear strain of tissue damage of patients lying on a spine board. While this information is interesting and even helpful, it does not tell nurses how best to care for a suspected spinal injury. The study is therefore excluded as it will not answer the present research question.

22. STUDY ID

Nemunatis s19

REASON FOR EXCLUSION

"Therefore, with the knowledge that individuals with a suspected acute SCI may be at increased risk for the formation of a pressure ulcer (Mawson et al., 1988) while strapped to a spine board for 1 to 5 hours (Cordell et al., 1996; Lerner & Moscati, 2000; Yeung et al., 2006), one might conclude that any localized pressures above 60mmHg may predispose the patient to pressure ulcer formation (Husain, 1953; Kosiak, 1961)."

"The objective of this study was to evaluate sacral interface pressure and sensing area in healthy volunteers during prolonged standard spinal immobilization on a spine board and the effect of a gel pressure dispersion liner (PDL)."

It is already known that a relatively short time spent on a spine board will results in tissue damage/pressure ulcers. It is also already known that a soft surface causes less tissue damage than a hard one. This study adds value by describing the value of adding a gel liner to a hard surface. While this information is interesting and even helpful, it does not tell nurses how best to care for a suspected spinal injury. The study is therefore excluded as it will not answer the present research question.

23. STUDY ID

Hemmes s195

REASON FOR EXCLUSION

"Prolonged immobilisation on the spineboard causes significant discomfort and pain (Kwan and Bunn, 2005) and, on occasions, may cause pressure ulcers to develop adjacent to bony prominences (Schouten et al., 2012). These ulcers are painful (Gunes, 2008; Pieper et al., 2009; Rastinehad, 2006) and debilitating for the patient (Fox, 2002; Hopkins et al.,

2006) and take a long time to heal (Bennett et al., 2004; Chapman et al., 2011; Sanada et al., 2011), resulting in prolonged hospitalisation (Allman and D.A.S.M., 1999; Graves et al., 2005) and reduced quality of life (Essex et al., 2009; Gorecki et al., 2009; Langemo et al., 2000; Spilsbury et al., 2007).”

“This cell damage triggers an inflammatory response involving the release of cytokines, such as IL1α, IL1RA and IL-8, into the skin. Previous studies (Bronneberg et al., 2006; Cornelissen et al., 2009) showed that IL1α can be detected after relatively short periods of loading time (<2 h) with its release related to the magnitude of pressure, and its release is up-regulated over sacral sites at which pressure ulcers are observed (Bronneberg, 2007; Lans van der, 2007)”

“The hypothesis for the present study was that lying on a rigid spineboard would result in an elevated release of IL1αand lactate as a result of the increased tissue-interface pressures when compared to lying on a soft-layered spineboard. In addition, we hypothesised that there would be a relationship between the pressure-induced reactive hyperaemia and the IL1α and lactate concentrations.”

It is already known that a relatively short time spent on a spine board will results in tissue damage/pressure ulcers. It is also already known that a soft surface causes less tissue damage than a hard one. This study adds value by describing aspects of the physiological inflammatory response to lying on the spine board. It also compares inflammatory markers released after immobilisation on a hard board with that of immobilisation on a softer surface. While this information is interesting and even helpful, it does not tell nurses how best to care for a suspected spinal injury. The study is therefore excluded as it will not answer the present research question.

24. STUDY ID

Kornhall as2

REASON FOR EXCLUSION

“The traditional prehospital management of trauma victims with potential spinal injury has become increasingly questioned as authors and clinicians have raised concerns about over-triage and harm. In order to address these concerns, the Norwegian National Competence Service for Traumatology commissioned a faculty to provide a national guideline for pre-hospital spinal stabilisation. This work is based on a systematic review of available literature and a standardised consensus process. The faculty recommends a

selective approach to spinal stabilisation as well as the implementation of triaging tools based on clinical findings. A strategy of minimal handling should be observed."

"Our recommendations, the quality of supporting evidence as well as the strength of recommendation are summarised in Table 2. The original studies supporting each

recommendation are listed and described in a separate evidentiary table that is available as supplementary material (Additional file 4)."

This systematic review was undertaken for the purpose of evidenced based guideline development. Although the search strategy is well described, there is only a brief description of results and very little detail on quality assessment and assessment of bias. This is probably because the article is primarily a National Guideline rather than a systematic review. the article was therefore excluded based on the paucity described above.

25. STUDY ID

Hood s54

REASON FOR EXCLUSION

"Two studies were in children aged less than eight; this age is of interest because of their large head-to-torso ratio.40,61 One study included eighteen children aged less than eight years with head or neck injury and who required cervical spine X-rays.40 Children with unstable vital signs, actual or potential cervical spine injury on history and, or physical examination were excluded.40 The other study was also in children aged"

The systematic review included paediatric patients, which was not in line with the eligibility criteria for this study.

26. STUDY ID

Phaily s201

REASON FOR EXCLUSION

All of the included articles in this systematic review were duplicated in other included systematic reviews, or in the primary inclusion for the systematic review at hand. The article was therefore excluded to avoid duplication of data.

27. STUDY ID

Otier s4

REASON FOR EXCLUSION

Five out of 8 included articles in this systematic review were also included in the review by Velopulos. The article was therefore excluded to avoid duplication of data.

28. STUDY ID

Martin as6

REASON FOR EXCLUSION

"10 experts were selected to form the sample as volunteers. These represent 71.4% (10/14) of the total teachers that the Emergency and Emergency Management 061 of the Region of Murcia designated in 2016 for training in initial care to trauma. The other experts declined their participation and/or did not attend the experiment appointment. This group of volunteers consists of 3 doctors, 3 nurses and 5 technicians. All participating professionals have more than 5 years of experience in pre-hospital emergencies and are life support instructors for the traumatic patient."

Although the intervention under investigation is relevant to the acute management of suspected spinal injury, the sample consisted of health care professionals rather than patients and therefore does not meet the inclusion criteria.

29. STUDY ID

Schubl s124

REASON FOR EXCLUSION

This article was included as a primary article in the systematic review by Velopulos. The systematic review by Velopulos was included in this systematic review and so the article by Schubl was excluded to avoid duplicating data.

30. STUDY ID

Kim s205

REASON FOR EXCLUSION

"In our study, the three cervical collars tested were: Philadelphia® Collar (Philadelphia Collar Company, Philadelphia, PA), Stifneck® Select™ Collars (Laerdal, Wappingers Falls, NY) and XCollar (Emegear)."

This study tested the efficacy of brand specific neck collars. It was decided to exclude the study as it cannot be assumed that these brands of collars would be used across emergency departments in South Africa. The external validity is therefore questionable and so the study was excluded.

31 – 41 STUDY ID

Prasarn s101

Del Rossi s103

Prasarn s104

Du Bosse s113

Prasarn s118

Del Rossi s139

Liao s148

Hyldmo s55

Prasarn s75

Holla as7

Hyldmo 156

REASON FOR EXCLUSION

12 cadaver studies were excluded on the basis that the results lack implications for practice relevant to the research question for this systematic review. The pre-determined eligibility criteria made provision for the inclusion of cadaver studies. Therefore, this research was not be excluded based on population. Instead, the external validity of the cadaver studies was discussed between the researcher and the supervisor. Following mutual agreement, the studies were excluded because it was established that the results stipulated would not be relevant to the nursing care of trauma patients with suspected spinal injury.

Total = 41

ADDENDUM G: CASP RANDOMISED CONTROLLED TRIAL

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Paper for appraisal and reference: Wampler s146

Section A: Are the results of the trial valid?

1. Did the trial address a clearly focused issue?

Yes	✓
Can't Tell	
No	

HINT: An issue can be 'focused' In terms of
- the population studied
- the intervention given
- the comparator given
- the outcomes considered

Comments: The issues of focus are the intervention and the outcome. The intervention is spinal immobilisation on the long backboard compared to spinal immobilisation on a stretcher mattress. And the outcome is reduced movement.

2. Was the assignment of patients to treatments randomised?

Yes	✓
Can't Tell	
No	

HINT: Consider
- how this was carried out
- was the allocation sequence concealed from researchers and patients

Comments: Healthy volunteers randomly selected a packet that contained, among other documents, a randomization card.

3. Were all of the patients who entered the trial properly accounted for at its conclusion?

Yes	✓
Can't Tell	
No	

HINT: Consider
- was the trial stopped early
- were patients analysed in the groups to which they were randomised

Comments: Data from the first participant was excluded because there was a problem with data collection. This data was excluded to avoid bias that may result from an extended period of time on the spine board. But this data was totally excluded and the sample was calculated without that participant.

Is it worth continuing?

CASP
Critical Appraisal Skills Programme

4. Were patients, health workers and study personnel 'blind' to treatment?

Yes	
Can't Tell	
No	✓

Comments: The ambulance driver was blind to the treatment, and the volunteers were blind to the hypothesis. But the volunteers and the evaluators at the back of the ambulance were not blind to the treatment.

5. Were the groups similar at the start of the trial

Yes	
Can't Tell	✓
No	

HINT: Consider
• other factors that might affect the outcome, such as; age, sex, social class

Comments: Both groups were healthy volunteers. But it does not specify if they were similar in terms of BMI, which may have affected the results. Although the text does report on the mean of the BMI for both groups.

6. Aside from the experimental intervention, were the groups treated equally?

Yes	✓
Can't Tell	
No	

Comments: Both groups followed the same protocol of immobilisation and a short drive in the ambulance, with the only difference being the presence or absence of a long spine board on top of the stretcher mattress.

Section B: What are the results?

CASP
Critical Appraisal Skills Programme

7. How large was the treatment effect?

HINT: Consider
- what outcomes were measured
- Is the primary outcome clearly specified
- what results were found for each outcome

Comments:	There is nothing in the text about treatment effect. But the primary and secondary outcomes are clearly defined, measured and reported on. Lateral motion is described in centimetres for each

8. How precise was the estimate of the treatment effect?

HINT: Consider
- what are the confidence limits

Comments:	Confidence interval 95% and results adjusted for BMI

Section C: Will the results help locally?

9. Can the results be applied to the local population, or in your context?

Yes	✓
Can't Tell	
No	

HINT: Consider whether
- the patients covered by the trial are similar enough to the patients to whom you will apply this
- how they differ

Comments:	Although the setting is a moving ambulance, the concept is generalisable to an ED.

10. Were all clinically important outcomes considered?

Yes	✓
Can't Tell	
No	

HINT: Consider whether
- there is other information you would like to have seen
- if not, does this affect the decision

Comments:	I think, given that healthy volunteers were used, the outcomes were sufficient.

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11. Are the benefits worth the harms and costs?

Yes	
Can't Tell	
No	✓

HINT: Consider
- even if this is not addressed by the trial, what do **you** think?

Comments:	I do not think there is benefit in using a spine board for the purpose of immobilisation. Perhaps to move a patient if no scoop is available.

ADDENDUM H: CASP COHORT STUDY

CASP
Critical Appraisal Skills Programme

Paper for appraisal and reference: Ala as5

Section A: Are the results of the study valid?

1. Did the study address a clearly focused issue?

Yes ☑
Can't Tell ☐
No ☐

HINT: A question can be 'focused' in terms of
- the population studied
- the risk factors studied
- is it clear whether the study tried to detect a beneficial or harmful effect
- the outcomes considered

Comments: Population and risk factors are not well defined, but it is clear that the study tries to detect a harmful effect of cervical collars, particularly on lung function.

2. Was the cohort recruited in an acceptable way?

Yes ☑
Can't Tell ☐
No ☐

HINT: Look for selection bias which might compromise the generalisability of the findings:
- was the cohort representative of a defined population
- was there something special about the cohort
- was everybody included who should have been

Comments: All patients in the ED with a collar, who could have the collar removed, were included. Exclusion seems reasonable as factors would have a significant effect on lung function and obviously alter the results.

Is it worth continuing?

CASP
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3. Was the exposure accurately measured to minimise bias?

Yes	
Can't Tell	✓
No	

HINT: Look for measurement or classification bias:
- did they use subjective or objective measurements
- do the measurements truly reflect what you want them to (have they been validated)
- were all the subjects classified into exposure groups using the same procedure

Comments: Insufficient detail to answer this question

4. Was the outcome accurately measured to minimise bias?

Yes	✓
Can't Tell	
No	

HINT: Look for measurement or classification bias:
- did they use subjective or objective measurements
- do the measurements truly reflect what you want them to (have they been validated)
- has a reliable system been established for detecting all the cases (for measuring disease occurrence)
- were the measurement methods similar in the different groups
- were the subjects and/or the outcome assessor blinded to exposure (does this matter)

Comments: Objective measurements were used. Spirometry and pulse oximetry were taken before and after collar removal and do indeed indicate lung volumes.

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5. (a) Have the authors identified all important confounding factors?

Yes ☐
Can't Tell ☐
No ☑

HINT:
- list the ones you think might be important, and ones the author missed

Comments: Several influencing factors were excluded, such as smoking and chest trauma, but no confounding factors for included patients were listed.

5. (b) Have they taken account of the confounding factors in the design and/or analysis?

Yes ☐
Can't Tell ☐
No ☑

HINT:
- look for restriction in design, and techniques e.g. modelling, stratified-, regression-, or sensitivity analysis to correct, control or adjust for confounding factors

Comments: No Report of co-founders

6. (a) Was the follow up of subjects complete enough?

Yes ☐
Can't Tell ☑
No ☐

HINT: Consider
- the good or bad effects should have had long enough to reveal themselves
- the persons that are lost to follow-up may have different outcomes than those available for assessment
- in an open or dynamic cohort, was there anything special about the outcome of the people leaving, or the exposure of the people entering the cohort

6. (b) Was the follow up of subjects long enough?

Yes ☐
Can't Tell ☑
No ☐

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Comments:	The article does not mention time in collar. It is specified that data was collected before and after collar removal, but no details regarding when in the timeline of patients stay this occurred.

Section B: What are the results?

7. What are the results of this study?

HINT: Consider
- what are the bottom line results
- have they reported the rate or the proportion between the exposed/unexposed, the ratio/rate difference
- how strong is the association between exposure and outcome (RR)
- what is the absolute risk reduction (ARR)

Comments:	

8. How precise are the results?

HINT:
- look for the range of the confidence intervals, if given

Comments:	Confidence intervals not provided. Results provided in standard deviations and percentages.

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Critical Appraisal Skills Programme

9. Do you believe the results?

Yes	
Can't Tell	✓
No	

HINT: Consider
- big effect is hard to ignore
- can it be due to bias, chance or confounding
- are the design and methods of this study sufficiently flawed to make the results unreliable
- Bradford Hills criteria (e.g. time sequence, dose-response gradient, biological plausibility, consistency)

Comments: One particular point for consideration is the position that the patient was in when the spirometry was measured. Supine position versus erect or sitting position would have had a significant effect on the parameters. The authors do not describe the position that the patient was in when the data was collected. So I am not sure if I believe the results. If the before and after was done in the same position, then the results may be believable. But if they were in a collar supine and then sat up for the

Section C: Will the results help locally?

10. Can the results be applied to the local population?

Yes	✓
Can't Tell	
No	

HINT: Consider whether
- a cohort study was the appropriate method to answer this question
- the subjects covered in this study could be sufficiently different from your population to cause concern
- your local setting is likely to differ much from that of the study
- you can quantify the local benefits and harms

Comments: This cohort is quite similar to a population in an SE ED. Were the results, valid, I do think they would be applicable.

11. Do the results of this study fit with other available evidence?

Yes	✓
Can't Tell	
No	

Comments: Other studies have reported dyspnoea as a side effect of spinal immobilisation.

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12. What are the implications of this study for practice?

Yes	
Can't Tell	✓
No	

HINT: Consider
- one observational study rarely provides sufficiently robust evidence to recommend changes to clinical practice or within health policy decision making
- for certain questions, observational studies provide the only evidence
- recommendations from observational studies are always stronger when supported by other evidence

Comments:	Implications are a bit vague, as the study was conducted on patients who could have the collar removed.

ADDENDUM I: CASP SYSTEMATIC REVIEW

CASP
Critical Appraisal Skills Programme

Paper for appraisal and reference: Velopulos s16

Section A: Are the results of the review valid?

1. Did the review address a clearly focused question?

Yes ☑ Can't Tell ☐ No ☐

HINT: An issue can be 'focused' In terms of
- the population studied
- the intervention given
- the outcome considered

Comments: Population is focused as patients with penetrating trauma, intervention is spinal immobilisation or spinal motion restriction. Comparator is no spinal immobilisation. Outcomes are mortality and

2. Did the authors look for the right type of papers?

Yes ☑ Can't Tell ☐ No ☐

HINT: 'The best sort of studies' would
- address the review's question
- have an appropriate study design (usually RCTs for papers evaluating interventions)

Comments: Randomised controlled trials prospective observational or retrospective studies and case control studies.

Is it worth continuing?

3. Do you think all the important, relevant studies were included?

Yes ☑ Can't Tell ☐ No ☐

HINT: Look for
- which bibliographic databases were used
- follow up from reference lists
- personal contact with experts
- unpublished as well as published studies
- non-English language studies

Comments: PubMed, Embase and Cochrane from 1980 to 2017. No language restrictions. "related articles" function used, citations scanned,

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4. Did the review's authors do enough to assess quality of the included studies?

Yes ☑
Can't Tell ☐
No ☐

HINT: The authors need to consider the rigour of the studies they have identified. Lack of rigour may affect the studies' results ("All that glisters is not gold" Merchant of Venice – Act II Scene 7)

Comments: Quality assessed using the GRADE system.

5. If the results of the review have been combined, was it reasonable to do so?

Yes ☑
Can't Tell ☐
No ☐

HINT: Consider whether
- results were similar from study to study
- results of all the included studies are clearly displayed
- results of different studies are similar
- reasons for any variations in results are discussed

Comments: Only 5 of the 24 studies were pooled into a meta-analysis. The authors describe exactly how they assessed heterogeneity and why some results were pooled and others were discussed descriptively.

Section B: What are the results?

6. What are the overall results of the review?

HINT: Consider
- If you are clear about the review's 'bottom line' results
- what these are (numerically if appropriate)
- how were the results expressed (NNT, odds ratio etc.)

Comments: No benefit was found for the use of spinal immobilisation in any of the outcomes.

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7. How precise are the results?

HINT: Look at the confidence intervals, if given

Comments:	CI are presented for 5 studies that were included in the Meta-analysis.

Section C: Will the results help locally?

8. Can the results be applied to the local population?

Yes	✓
Can't Tell	
No	

HINT: Consider whether
- the patients covered by the review could be sufficiently different to your population to cause concern
- your local setting is likely to differ much from that of the review

Comments:	The population and intervention are similar enough for this study to be generalised locally.

9. Were all important outcomes considered?

Yes	✓
Can't Tell	
No	

HINT: Consider whether
- there is other information you would like to have seen

Comments:	Mortality, Neurological deficit, failed intubation and missed injuries.

10. Are the benefits worth the harms and costs?

Yes	
Can't Tell	
No	✓

HINT: Consider
- even if this is not addressed by the review, what do **you** think?

Comments:	It is addresses and the authors do not suggest spinal immobilisation for patients with penetrating trauma.

ADDENDUM J: NARRATIVE DATA EXTRACTION

NARRATIVE DATA EXTRACTION

Section One

Date

6 July 2019

Title

Association between spinal immobilisation and survival at discharge for on-scene blunt traumatic cardiac arrest: a nationwide retrospective cohort study

First Author

Tsutsumi, Y

Year

2017

Design

Retrospective cohort study

Stated Objective

Investigate the temporal trend of performing spinal immobilisation on traumatic cardiac arrest patients and to examine the association between spinal immobilisation and survival at discharge in patients with on-scene cardiac arrest caused by blunt trauma.

Section Two

Geographical location

Japan (nationwide)

Study Setting

Pre-hospital environment and emergency departments in Japan

Population

Blunt trauma patients with suspected spinal injury who experienced on-scene cardiac arrest due to their trauma.

Sample

- n = 4313
- Immobilised: n = 3307, not immobilised: n – 1006
- Sample retrieved from The Japan Trauma Data Bank (2004-2015)
- Adult
- Trauma patients who were already experiencing cardiac arrest when EMS arrived on scene. (Cardiac arrest = pulseless, received chest compressions)
- Exclusion: Paediatric, not transferred directly from scene, treated by a physician on scene, time from call to EMS arrival more than 30 minutes, Abbreviated injury score 6 for any body part (not likely to survive).

Section Three

Intervention/Exposure

Spinal immobilisation versus no spinal immobilisation (backboard and/or collar)

Outcomes Sought

- **Primary outcome** = Survival at discharge
- **Secondary outcome** = Return of spontaneous rhythm (ROSC) by admission
- **Covariates** = age, gender, co-performed treatment by EMS, year of event, time from emergency call to EMS arrival on scene, Injury Severity Score, presence of Abbreviated Injury Score>3 at head, chest abdomen or pelvis.

Data Collection

Not really specified in the text, presumably a retrospective chart review.

Data Analysis

Described patient characteristics by comparing patient demographic factors between immobilised and non-immobilised patients.

- Continuous variables: expressed as means (SDV) or medians (IQR), t test or Wilcoxon's rank sum test used
- Categorical: variables shown as numbers (%), Pearson's chi-squared test for between group comparisons

Examine the association between spinal immobilisation and the probability of survival at discharge and the probability of ROSC by admission using a multivariable logistic regression model.

- All confounders included in multivariable logistic regression model as covariates
- Multiple imputation method to handle missing data
- Complete case analysis and sub-group analysis conducted for a sensitivity analysis.
- Sandwich covariance estimators used to account for hospital clustering
- Univariate regression model used to examine differences in the rate of survival among mechanisms
- Test of interaction used to assess association between spinal immobilisation and outcome in each sub-group

Results

Immobilised patients = IP. Non-immobilised patients = NIP

Patient Characteristics

- IP = 76.7%, NIP = 23.3%
- IP had a higher **ISS score** than NIP
- IP had a higher proportion of **chest injury** than NIP
- No difference in **time from EMS arrival to hospital arrival**
- 1.0% of IP and 0.9% of NIP had **severe cervical spine injury**
- **Missing values for survival at discharge** = 2.4%
- **Missing values for ROSC** = 4.9%
- **Usage rate of Spinal immobilisation** decreased from 82.7% in 2004-2006 to 74.0% in 3013 -2015
- **Crude survival proportion at discharge** increased from 1.2% in 2004-2006 to 2.8% in 2013-2015

Primary outcome

- 1.8% (57) IP survived to discharge
- 3.7% (33) NIP survived to discharge
- IP had a lower possibility of survival to discharge than NIP

Secondary outcome

- 25.0% (788) IP achieved ROSC by admission
- 41.9% (395) NIP achieved ROSC by admission
- IP had a lower proportion of ROSC by admission than NIP

Section Four

Stated Implications for Practice

As spinal immobilisation was significantly associated with a lower rate of survival at discharge and ROSC, the authors suggest that spinal immobilisation should not be routinely used for blunt trauma patients who are experiencing cardiac arrest.

Ethical & Funding

Approved by local ethics committee

ADDENDUM K: STATISTICAL DATA EXTRACTION

(This is an example of some of the information that was extracted onto a Microsoft Excel sheet)

Author	**n =**	**Outcome**	**Descriptive Statistic**	**Value**	**P Value**
Ala as5	50	FEV1 with collar	SDV	89.08 ±17.59	<0.001
		FEV1 without collar	SDV	98.26 ± 17.74	
Akkuş et al.	56	Group1 FEV1 Basal level	SDV	3.47±0.80	<0.001
		Group1 FEV1 0th minute	SDV	3.30±0.75	
		Group1 FEV1 5th minute	SDV	3.23±0.81	
		Group1 FEV1 30th minute	SDV	3.21±0.80	
		Group2 FEV1 Basal level	SDV	3.42±0.60	0.001
		Group2 FEV1 0th minute	SDV	3.23±0.60	
		Group2 FEV1 5th minute	SDV	3.28±0.61	
		Group2 FEV1 30th minute	SDV	3.30±0.61	

Işik et al	30	at 0˚ FEV1 Basal level	median (IQR%25-%75)	3.52(2.92-4.02)	<0.001
		at 0˚ FEV1 0th minute	median (IQR%25-%75)	3.08(2.83-3.66)	
		at 0˚ FEV1 30th minute	median (IQR%25-%75)	3.13(2.48-3.69)	
		at 20˚ FEV1 Basal level	median (IQR%25-%75)	3.59(2.94-4.03)	<0.001
		at 20˚ FEV1 0th minute	median (IQR%25-%75)	3.41(2.75-3.84)	
		at 20˚ FEV1 30th minute	median (IQR%25-%75)	3.07(2.70-3.75)	
Aksel	33	Cerebral Oxygen 0˚ 1st minute	SDV	77.97±7.56	0.220
		Cerebral Oxygen 0˚ 5th minute	SDV	78.74±7.47	
		Cerebral Oxygen 0˚ 30th minute	SDV	78.11±6.91	
		Cerebral Oxygen 20˚ 1st minute	SDV	76.89±6.99	0.768
		Cerebral Oxygen 20˚ 5th minute	SDV	77.05±7.52	
		Cerebral Oxygen 20˚ 30th minute	SDV	77.20±6.71	

Özdoğan et al	140	Right ONSD 0˚ 0th minute	median (IQR%25-%75)	5.5(5.3-5.6)	<0.001
		Right ONSD 0˚ 30th minute	median (IQR%25-%75)	5.8(5.5-5.9)	
		Right ONSD 0˚ 60th minute	median (IQR%25-%75)	5.8(5.6-6.0)	
		Right ONSD 20˚ 0th minute	median (IQR%25-%75)	5.5(5.3-5.6)	<0.001
		Right ONSD 20˚ 30th minute	median (IQR%25-%75)	5.7(5.5-5.9)	
		Right ONSD 20˚ 60th minute	median (IQR%25-%75)	5.8(5.5-6.0)	
Bruijns et al.	53	SBP at rest	95% CI	110.48-117.41	NR
			mean (mmHg)	114	
			median (mmHg)	114	
		SBP fully immobilised	95% CI	110.82-118.16	
			mean (mmHg)	115	
			median (mmHg)	112	
		SBP after logroll	95% CI	110.65-117.31	

			mean (mmHg)	114	
			median (mmHg)	114	
		SBP partially immobilised	95% CI	108.35-114.74	
			mean (mmHg)	112	
			median (mmHg)	111	
		SBP semi seated	95% CI	110.21-116.65	
			mean (mmHg)	113	
			median (mmHg)	113	

ADDENDUM L: ETHICAL APPROVAL

Title	Author	Ethical Approval as Documented
Cervical collar effect on pulmonary volumes in patients with trauma	Ala et al.	Approved by ethics committee of the Tabriz University of medical Sciences
Effects of spinal immobilization at 20° on respiratory functions	Akkuş et al.	Approved by local ethics committee Written informed consent obtained
Effects of 20-degree spinal immobilization on respiratory functions in otherwise healthy volunteers with android-type obesity	Işik et al.	Approved by ethics committee Written informed consent obtained
Effects of spinal immobilization at a 20°angle on cerebral oxygen saturations measured by INVOS™	Aksel	Approved by local ethics committee Approval number BD6556722642 Informed consent obtained
The effects of spinal immobilization at 20° on intracranial pressure	Özdoğan et al.	Approved by local ethics committee Written informed consent obtained
Effect of spinal immobilization on heart rate, blood pressure and respiratory rate	Bruijns et al.	Approved by the Research Ethics Committee at the NHS South West 1 (10/H0203/25) and at the University of Cape Town (014/2010) Informed consent obtained.
Effect of spinal immobilization with a long backboard and cervical collar on vital signs	Çorbacioğlu et al.	Approved by the ethics committee of Keçiören Training and Research Hospital B.10.4.ism.4.06.68.49 Written informed consent obtained
Association between spinal immobilization and survival at discharge for on-scene blunt traumatic cardiac arrest: A nationwide retrospective cohort study	Tsutsumi et al.	Approved by the ethics committee of Kyoto University School of Medicine (R0208-2)

Pressure ulcers, indentation marks and pain from cervical spine immobilization with extrication collars and headblocks: An observational study	Ham et al.	Official ethical approval not required as determined by The Medical Ethics Review Committee of UMC Utrecht (protocol number 12/161) Informed consent obtained
Pressure ulcers from spinal immobilisation in trauma: A systematic review	Ham et al.	Author emailed for confirmation. No reply by submission of report Assessed based on basic principles of ethical research
Comparison of a padded patient litter and a long spine board for spinal immobilization in air medical transport.	Weber et al.	Approved by the institutional review board
The long spine board does not reduce lateral motion during transport-a randomized healthy volunteer crossover trial	Wampler et al.	Approved by institutional review board at the University of Texas Health Sciences Centre Informed consent obtained
Value of a rigid collar in addition to head blocks: a proof of principle study	Holla	Author emailed for confirmation. No reply by submission of report Assessed based on basic principles of ethical research
The ability of external immobilizers to restrict movement of the cervical spine: a systematic review	Holla et al.	Author emailed for confirmation. No reply by submission of report Assessed based on basic principles of ethical research
Prehospital cervical spine motion: Immobilization versus spine motion restriction	Swartz et al.	Approved by institutional review board at the University of New Hampshire Informed consent obtained
Cervical spine immobilization in penetrating cervical trauma is associated with an increased risk of indirect central neurological injury	Turnock et al.	Approved by institutional review boards at the Tulane University, Louisiana State University Health Sciences Centre and The Hurley Medical Centre
Prehospital spine immobilization/spinal motion	Velopulos et	Author emailed for confirmation. No reply by

restriction in penetrating trauma: A practice management guideline from the Eastern Association for the Surgery of Trauma (EAST)	al.	submission of report. Assessed based on basic principles of ethical research
Cervical spine collar removal by emergency room nurses: A quality improvement project	Fontaine et al.	Not submitted to a research ethics committee as it was a practice improvement project. Approved by the hospital board and managers of the emergency department.
A multicenter program to implement the Canadian C-Spine Rule by emergency department triage nurses	Stiell et al.	Hospital research ethics boards either waived the need for approval or approved the program.

ADDENDUM M: LANGUAGE EDITING CERTIFICATE

Leatitia Romero
Professional Copy-Editor, Translator and Proofreader
(BA HONS)

Cell: 083 236 4536
leatitiaromero@gmail.com
www.betweenthelinesediting.co.za

17 October 2019

To whom it may concern:

I hereby confirm that I have language edited the dissertation entitled: "EVIDENCE-BASED NURSING CARE FOR SPINAL IMMOBILISATION – A SYSTEMATIC REVIEW". Any amendments introduced by the author hereafter are not covered by this confirmation. The author ultimately decided whether to accept or decline any recommendations made by the editor, and it remains the author's responsibility at all times to confirm the accuracy and originality of the completed work.

Leatitia Romero
(Electronically sent – no signature)

Affiliations

PEG: Professional Editors Group (ROM001)
EASA: English Academy of South Africa
SATI: South African Translators' Institute (1003002)
SfEP: Society for Editors and Proofreaders (15687)
REASA: Research Ethics Committee Association of Southern Africa (104)