

**FACTORS WHICH AFFECT THE APPLICATION AND IMPLEMENTATION OF A
SPINAL MOTION RESTRICTION PROTOCOL BY PREHOSPITAL PROVIDERS IN
LOW RESOURCE SETTINGS: A SCOPING REVIEW**

By

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TABLE OF CONTENTS

LIST OF FIGURES	5
ABBREVIATIONS	6
Part A: Background and Literature Review.....	7
Background	8
Introduction	11
Pathology of traumatic spinal cord injury	13
International best practice recommendations for prehospital management of traumatic spinal cord injury.....	15
Clinical spine clearance decision tools.....	17
Summary	24
References.....	26
Part B: Manuscript in Article Format.....	35
Title Page	36
Abstract	37
Figures	70
Part C: Appendices	101
Appendix A: Prehospital Emergency Care Journal: Instructions for Authors	102
Appendix B: Research Protocol.....	103
Appendix C: HREC Approval Letter.....	113

LIST OF FIGURES

Part A: Literature Review:

Figure 1: Prisma diagram detailing the literature review process..... 10

Part B: Manuscript:

Figure 1: Prisma diagram describing selection of articles for review.....67

Table 1: PRISMA-ScR Checklist.....71

Table 2: List of articles identified and included in the scoping review (n=42).....68

ABBREVIATIONS

C-COLLAR	Cervical Collar
CCSR	Canadian C-Spine Rule
CPG	Clinical Practice Guideline
CSI	Cervical Spinal Injury
C-spine	Cervical Spine
CT scan	Computed Tomography Scan
ED	Emergency Department
EMS	Emergency Medical Service
GCS	Glasgow Coma Scale
HEMS	Helicopter Emergency Medical Service
HIC	High Income Country
HPCSA	Health Professions Council of South Africa
LSB	Long Spine Board
MOI	Mechanism of Injury
MVC	Motor Vehicle Collision
NEXUS	National Emergency X-Radiography Utilization Study
PBEC	Professional Board for Emergency Care
SATS	South African Triage Scale
SCI	Spinal Cord Injury
SMR	Spinal Motion Restriction
TSCI	Traumatic Spinal Cord Injury

Part A: Background and Literature Review

Background

Over the last three decades, the South African Emergency Medical Service (EMS) landscape has undergone significant changes in prehospital emergency care training and education. These changes surfaced from the need for improved training of those dealing with emergency situations (1). It was viewed that most EMS short course qualifications' scope of practice and skills were found to be outdated and non-complaint with international best practice recommendations (1) Historically, this had resulted in a diverse number of short course and higher education qualifications in the South African EMS setting, with a follow-on effect of five different registration categories and scope in the practice of pre-hospital emergency care (2). To a large extent, these changes affect the provision of optimal patient care in the prehospital environment of South Africa. Moreover, South Africa, considered an upper-middle-income country, has several resource-constrained provincial EMS settings, which may also affect patient care.

The 2018 South African EMS Clinical Practice Guideline (CPG), much like any other CPG, was developed to improve and provide standardisation of quality in health care, avoid incidences of ineffective interventions, and maximise the best possible patient outcomes (3) within each respective EMS registration category. Most importantly, it aimed to provide emergency care suggestions in line with international best practice recommendations. One of the CPG recommendations made for the provision of optimal patient care involved that of the adoption and use of spinal clearance decision tools, namely the National Emergency X Radiography Utilization Study (NEXUS) and, or the Canadian C-Spine Rule (CCSR), for use by EMS personnel (4). These were based on the premise that the prevalence of spinal cord injury after blunt trauma is low (5-7) and, as a result, argues that the practice of spinal motion restriction (SMR) is unnecessarily performed by EMS personnel. Moreover, a growing body of evidence advises that SMR is not without its harmful effects (8), thereby indicating that the risks and adverse effects of the practice of SMR may far outweigh its presumed benefits. Whilst it is commendable that South Africa aims to integrate evidence-based practices within its setting, it is important to note that both the NEXUS and CCSR decision support tools were initially validated in the hospital setting of high-income countries (HICs), that being the United

States of America and Canada respectively (9-11) Furthermore, the extended practice recommendation of these decision support tools for prehospital use was mostly for those EMS having well-resourced services and a somewhat less complex EMS landscape in relation to education, training, skill and scope of practice than that of South Africa. With this in consideration, it is important to remember that the effectiveness of any CPG is reliant on how consistently they are used in clinical practice and decision-making (3). As a result, the safety and efficacy findings of practice adoption may not necessarily be generalisable to different practice environments, especially that of resource-constrained and differently structured EMS settings.

The following literature review was undertaken in order to provide foundational knowledge on the specific topic of SMR in the prehospital setting, most specifically to:

- A. Describe the pathology and prevalence of traumatic spinal cord injury (TSCI)
- B. Identify and describe the best practice recommendations for prehospital management of TSCI
- C. Review the current local and international information to identify SMR decision support tools used by EMS personnel across various settings.
- D. Identify the drivers of any gaps between SMR evidence and SMR practice

A limited literature search of the Medline database using the Pubmed search function was undertaken. The following advanced search string with medical subject headings (MeSH) relevant to SCI and Spinal immobilisation was used in the first instance:

("Emergency Medical Services"[Mesh] OR "Emergency Medical Service*"[tw] OR Paramedic[tw] OR Prehospital[tw]) AND ("Spinal Injuries"[Mesh] OR "Spinal cord injury*"[tw]) AND ("Immobilization"[Mesh] OR "Spinal Clearance"[tw] OR "spinal immobilization"[tw] OR "spinal motion restriction"[tw])(Figure 1). Following review, a total of 67 articles were included in this literature review. The inclusion and exclusion criteria utilised were articles involving spinal motion restriction or clinical spine clearance decision tools, articles in English and published between 2000 and 2020 and the study population were Emergency Medical Services and Emergency Department (ED) personnel.

This search string produced 289 potential hits, where 47 articles known to the author was also included. Article titles and abstracts were then screened for potential relevance and duplicate articles were removed. The full text of articles identified was then reviewed, where any articles which did not hold any relevance to the topic were excluded. Figure 1 below depicts the literature review process.

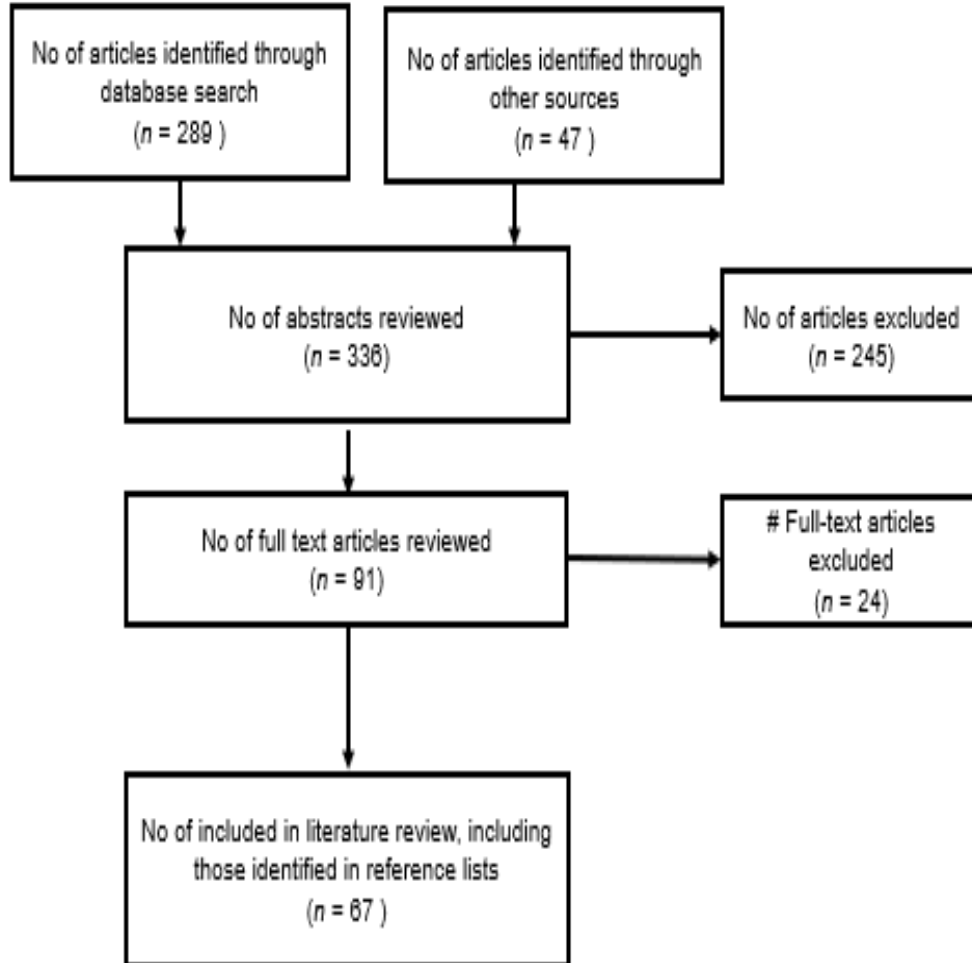


Figure 1: Prisma diagram detailing the literature review process

Introduction

Instability of the spine occurs when the integrity of the spinal column has been compromised. This instability can be the result of fractures and/or joint dislocations, which cause it to lose its ability to maintain its protective configuration under normal physiological loading. This places the spinal column at an increased risk of injury (12). Injuries to the spinal cord can occur at different levels, including cervical, thoracolumbar, and lumbosacral, where its severity may be classified as complete or incomplete (13). These may present differently, from that of pain to complete paralysis.

International published literature suggests that the prevalence of traumatic spinal cord injury (TSCI) after blunt trauma is low (3-25%) (7). Where a review indicates that epidemiologically, 55% of all spinal lesions are cervical, 15% thoracic, 15% thoracolumbar and 15% lumbosacral, the most common being C4-C5-C6, T4- T5 and T12-L1 (14). Researchers such as Chiu et al. highlight differences in the respective reporting of the incidence rates of TSCI between that of developing and those of developed countries (15). These variations might be influenced by underreporting and /or underdiagnosing cases with TSCI, which may also include increased numbers of patients who may have died on scene due to potential inappropriate handling, triage and transportation (15). No matter the setting and the prevalence of TSCI, unrecognised injury to the cervical spine can cause catastrophic neurological disability (16).

Prehospital EMS plays an integral role in providing care to enhance recovery and quality of life in patients who sustain TSCI. As a result, the routine practice by EMS has historically been to assume the presence of an unstable spinal injury when the patient presents with a relevant mechanism of injury (MOI) or clinical findings. Thereafter, EMS practitioners were to proceed and stabilise the patient using a combination of appropriate immobilisation devices, which included cervical collars (c-collars), head blocks, long spine boards (LSB), and straps, followed by transporting them to the closest hospital facility for the continuation of care. This practice was commonly referred to as traditional spinal immobilisation (17). However, over the last few decades, the potential dangers and sequelae of traditional spinal immobilisation have been extensively reported. Broadly these fall within four categories: increased pain, tissue breakdown, respiratory

compromise, and ineffective motion restriction (8). As a result, it is believed that these risks may far outweigh the presumed benefits that immobilisation provides trauma patients (5-7,9,10,18). There has also been a growing body of evidence that has highlighted concerns over the management approach of EMS personnel to potential TSCI patients (7) (7). Amongst others, a low probability of spinal cord injury (SCI) post-trauma exists, which is specifically linked to the force of impact needed to cause injury (5-7). This low prevalence is suggestive that immobilisation is being unnecessarily applied and that it leads to over-immobilisation of patients (12,19,20). Moreover, the term immobilisation has also been described as misleading since total non-movement is near impossible in achieving (5). It has since been replaced with the term spinal motion restriction (SMR), which is more descriptive of the desired outcome (5,8).

The above-cited concerns have prompted that the prehospital approach to TSCI is more refined (5,7,12). Specifically, that SMR decision-making should consider given indications and/or criteria that either warrant for or against its practice (21). It was generally believed that developing a selective SMR decision support tool would help reduce the number of SMR patients and, consequently, reduce the number of complications associated with this practice (22). Several organisations and publications have since recommended using a decision support tool in the prehospital setting which will facilitate a rapid and valid on-scene decision (5,7). These recommendations have gained support from research demonstrating that the adoption of such tools can be safely and effectively applied by EMS personnel within the prehospital setting (5,7,10,12,20). As such, the 2018 issue of the South African EMS CPG has supported this notion as a means to avoid unnecessary SMR and its associated risks (5-7,9,10,18). These CPGs have specifically suggested the NEXUS decision tool and, or the use of the Canadian C-Spine Rule (CCSR) in its setting. These are both considered clinical spinal clearance decision tools, initially designed and validated for use in the hospital setting (10,11, 23-28), a healthcare setting that is uniquely different from the prehospital environment (6,29,30).

The applicability of many decision support tools is subject to many limitations. For example, the CCSR and NEXUS were developed for use in conscious and orientated patients (10,11,23-28). In addition, although several SMR decision tools have specifically

been developed and recommended for use by EMS personnel in prehospital settings around the globe (21,31-35). Often some do not consider the current status of the patient (stable or unstable) (9, 31,36), or they are only applicable when the patient's circulation has been stabilised (10). To our knowledge, there exists no universally applicable prehospital SMR supporting tool that incorporates the unique EMS setting and patients that they encounter, which, as mentioned, is somewhat different from that of the hospital setting.

Moreover, currently available research concerning SMR decision tools is mostly based on research conducted in well-resourced settings (12,37-42). These results cannot necessarily be generalisable to poorly resourced settings, or those with very different EMS systems in place from those of the original studies investigated. Additional variables may exist that may facilitate or constrain the adoption and application of such decision tools in these prehospital settings. Therefore, it is important to investigate what they are to allow EMS to plan accordingly to effectively roll out a selective SMR decision instrument fit for its specific prehospital setting and population.

Pathology of traumatic spinal cord injury

Physical trauma is an injury to the body produced from impact, violence, or accident and is an omnipresent emergency commonly encountered within healthcare settings across the globe (43). Physical trauma is categorised as either penetrating injury or blunt trauma injury. This can be further classified by injury severity based on the cause of injury, the age of the patient and the area of the body affected. Injury severity can thus be categorised as minor, moderate, serious, severe, critical or non-survivable (44). Traumatic spinal injury is a broadly defined term that considers injury to bony, ligamentous, and or neurologic structures of the spinal column (45). Thus, spinal cord injury or nerve root injury is a recognised complication of spinal trauma (46), commonly defined as TSCI. Traumatic spinal cord injury is considered a severe injury, leading to significant mortality and morbidity (45).

Unrecognised injury to the cervical spine can cause catastrophic neurological disability, and therefore forms part of the initial prehospital management workup of the trauma patient (18,47). Identifying severe and critical injuries early on affects decision-making

regarding management interventions and that of transfer to definitive care (48). Unfortunately, patient deterioration may be directly associated with combined factors such as; the limited availability of appropriately trained staff, prolonged distance travelled by road from the scene to an appropriate treatment facility, poorly resourced ambulances or response vehicles (49), as well as the personnel's motivation for staying up to date with skills and best treatment recommendations (50). Moreover, limited EMS quality assurance systems may further predispose the patient to increased risk of mortality and morbidity post-trauma (51).

For years, the standard approach by EMS to the management of blunt trauma patients was to assume the presence of a potential TSCI and motion restrict all patients based on the MOI. This practice has come into question as recent evidence suggests that the estimated minimum force needed to cause injury to the spine is 1000N (52) and 3000N to injure the lumbar spine (53), thereby asserting that the probability of TSCI is relatively low (5, 52,53). Contrary to this, other published data found that C-spine fractures' incidence was less common than that of thoracolumbar fractures, specifically fractures between T11 and L4 (54). It is assumed that contradictions in the reporting on the incidence of SCI in general may be associated with several factors. Amongst others, this includes the differences in populations from those of well-resourced versus those from less-resourced countries with respect to the MOI involved and its associated patterns of injury to the spine, the underreporting and/or underdiagnosis of TSCI, and a potential increase in number of patients who died prior to arrival at hospital which may have resulted from a delay in, or lack of EMS response, and inappropriate handling or transportation of patients (15). There may be further variations in the prevalence of TSCI found attributed to human and equipment resources at hand, i.e. the method of spinal injury detection used within the various studies such as plain radiographic imaging versus computed tomography (CT) scan, with consideration that the CT scan is the most appropriate diagnostic tool for the detection of SCI (15).

Moreover, the increased emphasis on a blanket approach to traditional spinal immobilisation of all trauma patients, which EMS personnel have grown accustomed to, has to some extent shifted the best practice approach of TSCI that EMS personnel ought

to have. This being that TSCI is a two-step process that involves primary and secondary mechanisms (55). Primary mechanisms refer to the initial MOI (force on the body) that cause local deformation to the spine and its structures, and secondary injury subsequent to the primary injury encompasses a cascade of biochemical and cellular processes (55). Both primary and secondary injuries may be a neglected aspect of TSCI prevention. This may be due to the lack of awareness and consideration of the characteristics of traumatic spinal injury after trauma. Additionally, sustaining multiple injuries in the face of acute TSCI adds further concern of secondary injury to the spinal cord as these may precipitate hypotension and hypoxia, which exacerbate TSCI (55). It is thus important to acknowledge that as much as EMS should have concerns related to minimal patient handling of patients with possible TSCI in the prehospital setting (5), there should be equal concern shown toward the importance of management interventions that may mitigate against the consequences of secondary injuries.

International best practice recommendations for prehospital management of traumatic spinal cord injury

Often EMS are the first point of contact for patients and thus play a key role in improving the neurological outcome of patients in the prehospital setting (48). This is achieved by emergency response teams that have complex, decisive leadership ability and technical skills in their management of such patients (48). Moreover, the management approach to potential TSCI patients should be focused on SMR practices and appropriate transportation decision making, effective resuscitation efforts, prevention of hypoxia, and the management of hypotension to avoid secondary TSCI progression (48).

The historical approach to blunt trauma patients with potential TSCI in the prehospital setting mostly involved using a cervical collar, head blocks, and an LSB for full-body immobilisation. This was referred to as the traditional spinal immobilisation method (17), which was primarily performed to minimise or prevent further damage to the spinal cord, resulting in further instability of the spinal column (7,21,56). Two forms of traditional spinal immobilisation exist: C-spine immobilisation includes the usage of neck collars and head blocks, intended to protect the potential C-spine injury and prevent injury progression (37) whereas full spinal immobilisation provides for the use of spider harnesses, LSB or scoop

stretchers and/ or vacuum mattresses to avoid movement in lower areas of the spine (17). Of late, EMS protocols have evolved to such a degree that spinal immobilisation, especially full immobilisation, which makes use of LSB, is no longer recommended for routine prehospital use (57,58). Instead, it has been advocated that patients be managed by a technique referred to as SMR, which excludes the routine use of the LSB and scoop stretcher devices, as these should preferably be used for the purposes of extrication and movement on the scene only (5,17). The rationale for this protocol change derives from documented complications to patient and operational considerations which are associated with its packaging and transportation use.

Furthermore, there are several risks and complications associated with SMR practices in general. These can be broadly described within four categories (8): increased pain, tissue breakdown, respiratory compromise, and ineffective motion restriction. For example, in C-spine immobilisation, there have been reports on the increased movement of unstable fractures, increased intracranial pressure, and causing tissue necrosis and general discomfort for the patient (5,18). One article in particular by Bengner and Blackman (59), explored the reasoning behind the use of cervical collars in conscious trauma patients and have suggested that its comfortability makes the task of effectively examining the patient more difficult. Other documented SMR concerns also include that prolonged motion restriction is linked to the development of pressure ulcers and general patient discomfort and pain (57,59). Also, SMR is time-consuming and may delay transportation and, therefore, definitive treatment of patients (30,60). Additionally, some patients may experience motion sickness at the back of an ambulance, in this way, increasing the risk of aspiration (59,61). Moreover, the prolonged use of SMR devices has resulted in the increased rate of iatrogenically induced pain, further complicating patient assessment on arrival at the ED as it leads to false-positive findings (57,62). All of these factors further contribute to poor patient satisfaction in that it results in significant unnecessary health care costs (62), and also increases the utilisation of C-spine imaging, thereby increasing patient exposure to radiation (10,11,25).

Due to the growing number of concerns raised about SMR, it was suggested that developing a more selective SMR protocol could reduce the number of patients' motion

restricted in the prehospital setting. Thereby decreasing the number of potential risks and complications associated with it (22). Currently, several selective SMR protocols (also referred to as spinal clearance protocols) exist, many of which were initially designed for indications requiring radiological imaging in the ED and later validated for prehospital use (22,32,61,63,64). The aim of a prehospital selective motion restriction protocol is to identify either those patients who are at low risk of sustaining SCI and can thereby be transported without SMR and to identify those patients at increased risk who ought to be motion restricted (38,63). The South African CPGs have proposed using the NEXUS and/or the CCSR tools for use by EMS personnel.

Clinical spine clearance decision tools

The NEXUS rule and the CCSR are clinical spine clearance decision tools initially designed and validated for use in the hospital settings of the United States and Canada, respectively (9-11). These clinical decision tools have afforded healthcare providers the opportunity to make evidence-based, objective decisions about whether or not imaging is required, these result in cost-saving practices as well as reduced radiation exposure to patients (65).

National Emergency X Radiography Utilization Study (NEXUS) criteria

In a large multicentre trial, Hoffman et al. (9) validated five criteria indicating a low probability of C-spine injury. Thereby in the hospital setting, the absence of all five criteria determined and helped the healthcare practitioner identify those patients who did not require imaging (9,65). These criteria are known as the NEXUS criteria and include:

- Altered level of consciousness/ alertness. Altered level of consciousness/ alertness being defined as patients who present with:
 - Glasgow Coma Scale (GCS) of less than 15
 - Disorientation to person, place, time or events
 - Inappropriate response to external stimuli
 - Inability to remember three objects in five mins
- Any indication of intoxication
- Posterior midline cervical tenderness

- Focal neurological deficit
- Presence of any clinically apparent, painful distracting injury
 - Examples of distracting injuries may include: visceral injury requiring surgical consultation, long bone fractures, extensive burns or crush injuries.

It is postulated that should EMS use this decision tool within the prehospital setting; it will indicate those patients who do not need C-spine immobilisation.

The Canadian C-Spine Rule (CCSR) criteria:

The CCSR is another clinical spine clearance tool that was initially developed for use in alert, stable patients who presented to the Canadian ED settings. This decision tool validated several high-risk criteria (the high likelihood of C-spine injury to the spine), which can be used to identify which patients are at increased risk of having sustained a traumatic spinal injury, thereby requiring further radiology examination (38), or in the prehospital setting, those requiring C-spine immobilisation. This tool does this by placing emphasis on high-risk MOI and physical examination (66). These criteria include (10):

Any high-risk factor that mandates radiography which includes:

- Age 65 years or older
- Dangerous mechanism:
 - Fall from 1m (or five stairs)
 - Axial load to the head (e.g., diving accidents)
 - Motor vehicle collisions (MVC) at high speed (>100 km/h)
 - Motorised recreational vehicle accident
 - Ejection from a vehicle
 - Bicycle collision with an immovable object
- Paraesthesia in extremities
- Any low-risk factor that allows safe assessment of the range of motion. Range of motion testing entails the examination of whether the patient can actively rotate the neck 45 inches to the left and right (regardless of pain). Should the patient be able to rotate his or her neck, imaging (or SMR) is not indicated

(Patients who do not have any of the following low-risk factors should be radiographed/ motion restricted and are not suitable for the range of motion testing):

- Simple rear-end motor vehicle collision
- Sitting position on-scene/ in the ED
- Ambulatory at any time since injury
- Delayed onset of neck pain
- Absence of midline C-spine tenderness

Overall, the CCSR was found as the most specific clinical criteria for C-spine injury, where the NEXUS rule is found to be less sensitive (90.7% vs 99.1%) and less specific (36.8% vs 45.1%); thus the recommendation for the use of CCSR over NEXUS (10). Furthermore, a prospective study by Vaillancourt et al. (38) aimed to validate the safety of application of the CCSR tool when used by paramedics in the prehospital setting. This study included the following three criteria (38):

❖ **Criterion 1: Any high-risk patient**

These include:

- Age >65
- Any dangerous MOI, or
- Numbness or tingling in the extremities

Positive findings of criterion 1 mandate that C-spine immobilisation be applied, whereas the absence of which leads to further assessment in criterion 2

❖ **Criterion 2: Low risk**

Includes:

- Simple rear-end MVC
- Ambulatory at any time whilst on scene
- The absence of neck pain at the scene when asked, or
- No pain during midline palpation.

The presence of any of these conditions leads to further assessment of criterion 3

❖ **Criterion 3: Neck mobility**

- Patients ability to voluntarily rotate the neck 45 degrees left and right upon request.

The inability to rotate the neck mandates that the patient be motion restricted.

This study revealed that approximately 40% of patients having sustained blunt trauma injury could be safely transported without C-spine immobilisation (38).

Possible concerns/ challenges with NEXUS and CCSR use within the prehospital setting

Within the literature, several possible concerns are highlighted regarding the NEXUS and CCSR tools which can create specific challenges when used by EMS personnel. Amongst others, these include the following:

- I. As the initial tools were developed for the ED setting, a large subgroup of patients was omitted in the derivation set of the CCSR (10), hence questioning the generalisability of usage (67) in other settings such as that of South Africa.

In particular, the excluded groups include those with a decreased GCS and those with abnormal vital signs (respiratory rate 10 – 24 breaths per minute and/ or systolic blood pressure less than 90 mmHg) (6). It is anticipated that resourced constrained EMS' such as those found within South Africa may encounter these excluded subgroups of patients more often due to the severity of MOI and delays in arriving at the scene (49).

- II. The unreliability of the decision tool in identifying lower spinal injuries

Hospital use of both CCSR and NEXUS has been deemed unreliable in identifying lower spinal injuries (5,66). In one study, more than half (52%) of patients with known thoracolumbar fractures had a negative clinical examination (68). For the prehospital setting, where there is a need to make appropriate transportation packaging decisions, they may benefit more from an SMR protocol that considers injury to the entire spine and not only (purely) that of the C-spine. This may be more relevant since most literature points out that there are harms and adverse

events associated with SMR packing devices in general, not only those used for C-spine immobilisation.

III. Prevalence of TSCI and other high-risk factors

The CCSR, which considers high-risk MOI for C-spine injury factors such as advanced age (>65 years old), may not be equally representative of those patients at high risk within the South African population group. A prospective study by Joseph et al. (69) evaluating the incidence and aetiology of TSCI in Cape Town, South Africa, found that younger men were at greater risk of injury. It found that 85.5% of TSCI patients were males, where the male to female ratio was 5.9:1 (69). Of these male patients with TSCI, 54% were 18 – 30 years old, and 6% of men were in the age category of >65 years in age (67). Additionally, this study found that the annual crude incidence of TSCI was amongst the highest globally, with a reported 75.6 per million for the population under study (69). This was a higher rate than neighbouring countries such as Botswana, with an incidence rate of 13 per million population (69,70). These findings from one population-based study in an urban area in South Africa suggest that there may be a higher probability of sustaining TSCI in the South African setting compared to international settings. Therefore, there may be differences in those patients at higher risk of TSCI within the South African context that the internationally adopted CCSR does not consider.

IV. False-negative criterion result

Although there is some evidence supporting the adoption of an SMR protocol, other evidence identified by a systematic review of prehospital SMR protocols suggests that more research is needed to determine the safety of prehospital SMR in general (71). Interestingly, this review was based on SMR evidence within HICs EMS. This review found that many elderly patients who sustained thoracic spinal or lumbar spinal injury were omitted from the SMR as they were viewed as false negatives by the motion restriction protocol. These resulted from sustaining injury

due to a low-risk MOI with minimal force, such as falling from standing (71). Moreover, the review highlighted three areas where motion restriction was regularly omitted - the elderly, those injuries with a minimal force of impact and patients with thoracic and lumbar injuries (71). This evidence highlights the view that it could be very dangerous to assume the benefits of conferred treatment being made by SMR protocols and pre-hospital practitioner use thereof without considering the population affected by such protocols, i.e. patient, practitioner, EMS system, and demographic trends in addition to the characteristics of the TSCIs.

V. Appropriate experience and education of the practitioner

Brown et al. (72) suggested that appropriate implementation of SMR by EMS practitioners requires intensive education and vigilant, quality-assurance examination. Within the South African EMS, quality assurance systems are scarce. Moreover, its EMS have five professional registration categories, which range from supervised to independent categories, where those who have received extensive training are limited in number operationally. National health data from November 2018 indicates that 94% of prehospital operational staff within the Free State provincial setting are short course holders (2 – 4-month training courses). It is thus important that EMS policy-makers consider certain strategies before encouraging the adoption of internationally validated clinical spinal clearance decision tools. These include the evaluation of appropriate methods to train staff and the implementation of quality assurance systems.

With consideration to these concerns cited above, it is believed that the South African EMS may have benefited more from the development or adoption of modified selective SMR criteria to help increase the specificity and sensitivity of selective criteria when used within its setting. Other EMS settings have incorporated this aspect by developing a modified SMR protocol for use (48). Thus, several other modified SMR protocols exist across the globe that are based on the NEXUS and, or CCSR decision tools. Amongst others, these EMSs included that of England (36), South-eastern Michigan (33), and

Ambulance Victoria in Australia (16). Whilst other EMS settings, such as that of New Jersey (35) have first researched comparing different selective SMR protocols, based on these results, identify an appropriate decision instrument that its services can best utilise.

Potential Drivers of Gaps Between SMR Evidence and SMR Practice

Globally several EMS have, to some extent, incorporated a selective SMR decision tool for use within its services, where its safety in the application has been demonstrated. Studies by Stroh et al. (30) and Armstrong et al. (36) are two examples of studies that have demonstrated such positive findings. However, there is other literature that questions the safety and accuracy of EMS' use of an SMR decision tool. Brinke et al. (22) acknowledged that whilst the EMS practitioner can indeed predict the presence of spinal fractures using such tools; it points out that this is done with a low degree of accuracy (41%). Thus, the implementation of a protocol based on the predictions of paramedics will not necessarily reduce the overuse of SMR (22). What is interesting in this study is noted within the limitations pointed out, being that the low accuracy of prediction may be associated with the level of experience of the paramedic. Overall, these differences in reporting may be indicative that there may exist different factors which may either delay or inappropriately translate evidence into practice within various EMS settings.

In South Africa, we currently observe the continuation of traditional spinal immobilisation practices amongst EMS personnel, despite the new CPG recommendations and the wealth of literature currently available suggesting that traditional spinal immobilisation practices may cause more harm than good. There is a possibility that this may be attributed to the evidence to practice gap. An “evidence to practice gap”, also referred to as a “second translation gap” (73,74), is described as a delay in the translation of evidence-based interventions into everyday clinical practice. This may often result in unwarranted clinical practice variations (75), and in turn, may lead to different health outcomes for patients with the same aetiologies (3). Several factors may contribute to the complexities between evidence and practice, such as differences in staff capabilities and local protocols of care (3). In South Africa, a vast difference between the EMS capabilities and the scope of practice of staff already exists; moreover, having a local protocol that

prescribes the EMS personnel with a choice between two different clinical spine clearance decision support tools. These factors may negatively affect the safety and accuracy of implementation. Aiming to identify possible contributors to this knowledge translation gap in resource-constrained settings may help quality improvement projects as we strive to adopt evidence-based practice to improve patient care in similar settings.

Summary

This literature review identified several possible factors which may pose challenges to the appropriate adoption of a clinical spine clearance decision tool by EMS personnel. Whilst it is important to acknowledge that these challenges may exist, it is equally important to identify appropriate measures or interventions which may facilitate optimal patient care being delivered when implementing evidence-based practice. The evidence to practice gap is a reality and may be applicable to resourced constrained settings and any healthcare setting. As a starting point, we found it fit to conduct research that can identify both facilitators and barriers to appropriate SMR practice by EMS personnel and promote future research initiatives.

The researchers' view was that answers to some of the identified challenges in this literature review could not be addressed by a very specific systematic review of the literature. In this instance, the use of a scoping review was more beneficial than that of a systematic review, as selective SMR decision support tool adoption by EMS personnel is still a new concept, more so in resource-limited settings. Scoping reviews are useful when it is still unclear what other, specific questions can be posed and valuably addressed by a more precise systematic review as suggested by Munn et al. (76). Munn et al. (76) further suggest several other purposes for conducting scoping reviews, to which our scoping review will draw on four of the listed purposes, including:

- Identifying types of available evidence on selective SMR decision support tools by EMS personnel
- Clarifying key concepts and definitions in the literature on selective SMR decision support tools, and that of clinical spinal clearance decision tools
- Examining how such research was conducted

- Identifying key characteristics or factors related to selective SMR decision support tools, and
- Identifying and analysing the knowledge gaps around the topic.

The researchers believe that identifying barriers and facilitators of SMR decision tool adoption by EMS practitioners are essential components to successful knowledge translation. The scoping review will also pay specific attention to the supporting theories and principles for the development and decision making of the selective SMR practice recommendations for EMS personnel. With a set focus on how these recommendations were implemented, how they guide the SCI management approach, and ultimately affect patient care and outcome. The findings will be contextualised to the South African pre-hospital environment to identify gaps in the literature and the need for further research in this domain.

References

1. Sobuwa S, Med E, Denzil L, Mtech C. Education Emergency care education in South Africa : past, present and future. *Australian Journal of Paramedicine*. 2019;16:1–5. <https://doi.org/10.33151/ajp.16.647>
2. Cermak R. An Investigation Into Recognition of Prior Learning within the National Certificate: Emergency Care Programme in the Western Cape. Durban University of Technology. 2016;(Unpublished):180. Available from: <https://hdl.handle.net/10321/1741>
3. Sharwood LN, Dhaliwal S, Ball J, Burns B, Flower O, Joseph A, et al. Emergency and acute care management of traumatic spinal cord injury : a survey of current practice among senior clinicians across Australia. *BMC Emergency Medicine*. 2018;1–8. <https://doi.org/10.1186/s12873-018-0207-0>
4. Clinical Practice Guideline: Health Professions Council of South Africa Professional Body of Emergency Care. 2018. p97–108.
5. Stanton D, Hardcastle T, Muhlbauer D, Zyl D Van. Cervical collars and immobilisation : A South African best practice recommendation Minerves et immobilisations : Recommandation tirée des meilleures pratiques sud-africaines. *African J Emerg Med*. 2017;7(1):4–8. <http://dx.doi.org/10.1016/j.afjem.2017.01.007>
6. Connor D, Greaves I, Porter K, Bloch M. Pre-hospital spinal immobilisation : an initial consensus statement. *Emerg Med J*. 2013;30(12). <https://doi.org/10.1136/emered-2013-203207>
7. Theodore N, Hadley MN. Prehospital Cervical Spinal Immobilization After Trauma. *Neurosurgery*. 2018;72(3):22–34. <https://doi.org/10.1227/neu.0b013e318276edb1>
8. Feld FX. Removal of the Long Spine Board From Clinical Practice: A Historical Perspective. *Journal of Athletic Training*. 2018;53(8):752–5. <https://doi.org/10.4085/1062-6050-462-17>
9. Hoffman J, Mower W, Wolfson A et al. Validity of a Set of Clinical Criteria to Rule out Injury to the Cervical Spine in patients with blunt trauma. *New Engl J Med*.

- 2000;343(2):94-99. <https://doi.org/10.1056/nejm200007133430203>
10. Stiell IG, Wells GA, Vandemheen KL, Clement CM, Lesiuk H, Maio VJ De, et al. The Canadian C-Spine Rule for Radiography in Alert and Stable Trauma Patients. *JAMA* 2001;286(15):1841-1848. <https://doi.org/10.1001/jama.286.15.1841>
 11. Stiell I, Clement C, Rowe B, Al E. The Canadian C-Spine Rule versus the NEXUS Low-Risk Criteria in Patients with Trauma. *The New England Journal of Medicine*. 2003;2510-2518. <https://doi.org/10.1056/nejmoa031375>
 12. Kornhall DK, Jørgensen JJ, Brommeland T, Hyldmo PK, Asbjørnsen H. The Norwegian guidelines for the prehospital management of adult trauma patients with potential spinal injury. *Scand J Trauma Resusc Emerg Med*. 2017;1–11. <http://dx.doi.org/10.1186/s13049-016-0345-x>
 13. Cole AA. Spinal fractures in adults. *Surgery*. 2012;30(7):333–8. <http://dx.doi.org/10.1016/j.mpsur.2012.05.006>
 14. Cacho García S, Peña Otero D, Eguillor Mutiloa M. Efficacy of cervical immobilization in multiple trauma patients. *Int J Crit Care Emerg Med*. 2019;5(1). DOI: [10.23937/2474-3674/1510061](https://doi.org/10.23937/2474-3674/1510061)
 15. Chiu AW, Lin H, Lam C, Chu S, Chiang Y. Epidemiology of Traumatic Spinal Cord Injury: Developed and developing countries. *Asia-Pacific Journal of Public Health*.2010;22(1):9-18. DOI: [10.1177/1010539509355470](https://doi.org/10.1177/1010539509355470)
 16. Oteir AO, Smith K, Stoelwinder J, Middleton JW, Cox S, Sharwood LN, et al. Prehospital Predictors of Traumatic Spinal Cord Injury in Victoria , Australia. *Prehospital Emerg Care*. 2017;21(5):583–90. <https://doi.org/10.1080/10903127.2017.1308608>
 17. Swartz EE, Tucker WS, Nowak M, Roberto J, Decoster LC, Trimarco TW, et al. Prehospital Cervical Spine Motion : Immobilization Versus Spine Motion Restriction. *Prehospital Emergency Care*. 2018;3127: 630-636. <https://doi.org/10.1080/10903127.2018.1431341>

18. Sundstrøm T. Prehospital Use of Cervical Collars in Trauma Patients : A Critical Review. *Journal of Neurotrauma*. 2014;540:531–540. DOI: [10.1089/neu.2013.3094](https://doi.org/10.1089/neu.2013.3094)
19. Kwan I, Bunn F. Effects of prehospital spinal immobilization: A systematic review of randomized trials on healthy subjects. *Prehosp Disaster Med*. 2005;20(1):47–53. <https://doi.org/10.1017/s1049023x00002144>
20. Orledge JD, Pepe PE. Out-of-hospital spinal immobilization: is it really necessary? *Acad Emerg Med*. 1998;5(3):203–204. <https://doi.org/10.1111/j.1553-2712.1998.tb02612.x>
21. Kreinest M, Gliwitzky B, Schüler S, Grützner PA, Münzberg M. Development of a new Emergency Medicine Spinal Immobilization Protocol for trauma patients and a test of applicability by German emergency care providers. *Scand J Trauma Resusc Emerg Med*. 2016;1–10. <http://dx.doi.org/10.1186/s13049-016-0267-7>
22. Brinke JG, Pallada WKGL, Hogervorst TPSM. Value of prehospital assessment of spine fracture by paramedics. *Eur J Trauma Emerg Surg*. 2018;44(4):551–554. <https://dx.doi.org/10.1007%2Fs00068-017-0828-0>
23. Hauswald M, Braude D. Immobilization in the Emergency Department. *Academic Emergency Medicine Journal*. 2007;1087–9. DOI: [10.1197/j.aem.2007.04.020](https://doi.org/10.1197/j.aem.2007.04.020)
24. Hoffman J, Wolfson A, Todd K, Mower W. Selective Cervical Spine Radiography in Blunt Trauma : Methodology of the National Emergency X-Radiography Utilization Study (NEXUS). *Annals of Emergency Medicine*. 1998;32(4):461–469. [https://doi.org/10.1016/s0196-0644\(98\)70176-3](https://doi.org/10.1016/s0196-0644(98)70176-3)
25. Stiell IG, Clement CM, Grimshaw J, Brison RJ, Rowe BH, Schull MJ, et al. Implementation of the Canadian C-Spine Rule : prospective 12 centre cluster randomised trial. *Br Med J*. 2009;1–7. <https://doi.org/10.1136/bmj.b4146>
26. Consortium for Spinal Cord Medicine Clinical Practice Guideline. Early acute management in adults with spinal cord injury: A clinical practice guideline for health-care providers. *Journal of Spinal Cord Medicine*. 2008;31:427- 432. <https://dx.doi.org/10.1043%2F1079-0268-31.4.408>

27. Fehlings MG, Martin AR, Tetreault LA, Aarabi B, Anderson P, Arnold PM, et al. A Clinical Practice Guideline for the Management of Patients With Acute Spinal Cord Injury: Recommendations on the Role of Baseline Magnetic Resonance Imaging in Clinical Decision Making and Outcome Prediction. *Glob Spine J.* 2017;7(3_supplement):221S-230S. <https://doi.org/10.1177/2192568217703089>
28. Fehlings MG, Tetreault LA, Wilson JR, Kwon BK, Burns AS, Martin AR, et al. A Clinical Practice Guideline for the Management of Acute Spinal Cord Injury: Introduction, Rationale, and Scope. *Glob Spine J.* 2017;7(3_supplement):84S-94S. <https://doi.org/10.1177/2192568217703387>
29. Hankins DG, Rivera-Rivera EJ, Ornato JP, Robert A, Blackwell T, Domeier RM, et al. Spinal immobilization in the field: Clinical clearance criteria and implementation. *Prehospital Emergency Care.* 2009;3127: 88-93. <https://doi.org/10.1080/10903120190940416>
30. Stroh G, Braude D. Can an Out-of-Hospital Cervical Spine Clearance Protocol Identify All Patients With Injuries ? An Argument for Selective Immobilization. *Annals of Emergency Medicine.* 2001;37(6):609–615. <https://doi.org/10.1067/mem.2001.114409>
31. Burton J, Dunn M, Harmon N, Hermanson T, Bradshaw J. A Statewide, Prehospital Emergency Medical Service Selective Patient Spine Immobilization Protocol. *The Journal of Trauma Injury, Infection, and Critical Care.* 2006;61(1):161-167. <https://doi.org/10.1097/01.ta.0000224214.72945.c4>
32. Domeier R, Swor R, Evans R, Hancock B, Fales W, Krohmer J, et al. Multicenter Prospective Validation of Prehospital Clinical Spinal Clearance Criteria. *The Journal of Trauma Injury, Infection, and Critical Care.* 2002;53:744-750. <https://doi.org/10.1097/00005373-200210000-00021>
33. Domeier R, Evans R, Swor R, Rivera-Rivera E. Prospective Validation of Out-of-hospital Spinal Clearance Criteria : A Preliminary Report. *Academic Emergency Medicine.* 1997;4(6):643–646. <https://doi.org/10.1111/j.1553-2712.1997.tb03588.x>
34. Gonzalez R, Cummings G, Baker J, Frotan A, Simmons J, Brevard S, et al.

- Prehospital Clinical Clearance of the Cervical Spine : A Prospective Study. *The American Surgeon*. 2013;1213–1218.
<https://doi.org/10.1177/2F000313481307901128>
35. Hong R, Meenan M, Prince E, Murphy R, Tambussi C, Rohrbach R, et al. Comparison of Three Prehospital Cervical Spine Protocols for Missed Injuries. *West J Emerg Med*. 2014;15(4):471–479.
<https://doi.org/10.5811/westjem.2014.2.19244>
 36. Armstrong B, Simpson H, Crouch R, Deakin C. Prehospital clearance of the cervical spine: does it need to be a pain in the neck ?. *Emerg Med J*. 2007;501–3.
[DOI: 10.1136/emj.2006.041897](https://doi.org/10.1136/emj.2006.041897)
 37. Larson S, Delnat AU, and Moore J. The Use of Clinical Cervical Spine Clearance in Trauma Patients: A Literature Review. *J Emerg Nurs*. 2018;44(4):368–374. Available from: <http://dx.doi.org/10.1016/j.jen.2017.10.013>
 38. Vaillancourt C, Charette M, Kasaboski A, Maloney J, Wells GA, Stiell IG. Evaluation of the safety of C-spine clearance by paramedics : design and methodology. *BMC Emerg Med*. 2011;11(1):1-11. <https://doi.org/10.1186/1471-227X-11-1>
 39. Kreinest M, Goller S, Grützner BGPA, Häske MKD. Expertise of German paramedics concerning the prehospital treatment of patients with spinal trauma. *Eur J Trauma Emerg Surg*. 2017;43:371–376. <https://doi.org/10.1007/s00068-016-0682-5>
 40. Jin P, Goslings J, Luitse J, Ponsen J. A Retrospective Study of Five Clinical Criteria and One Age Criterion for Selective Prehospital Spinal Immobilization. *Eur J Trauma Emerg Surg*. 2007;(4):401–407. <https://doi.org/10.1007/s00068-007-6197-3>
 41. Fontaine G, Student RN, Forgione M, Mba RN, Rn FL, Rn ML, et al. Cervical spine collar removal by emergency room nurses: A quality improvement project. *J Emerg Nurs*. 2018;44(3):228–35. <https://doi.org/10.1016/j.jen.2017.07.018>
 42. Paykin G, Reilly GO, Ackland HM, Mitra B. The NEXUS criteria are insufficient to exclude cervical spine fractures in older blunt trauma patients. *Injury*.

- 2020;48(5):1020–4. <http://dx.doi.org/10.1016/j.injury.2017.02.013>
43. David JS, Bouzat P, Raux M. Evolution and organisation of trauma systems. *Anaesth Crit Care Pain Med.* 2019;38:161–7. <https://doi.org/10.1016/j.accpm.2018.01.006>
 44. Teasdale G. JB. Injury Severity Scoring / AAST Organ Grading Scales. *Lancet.* 2001;81–3. Available from: http://www.surgicalcriticalcare.net/Resources/injury_severity_scoring.pdf
 45. Kumar R, Lim J, Mekary RA, Rattani A, Dewan MC, Sharif SY, et al. Traumatic Spinal Injury: Global Epidemiology and Worldwide Volume. *World Neurosurg.* 2018;113:e345–63. <https://doi.org/10.1016/j.wneu.2018.02.033>
 46. Gummerson NW, Cole AA. Spinal fractures in adults. *Surgery.* 2009;27(7):287–91. <http://dx.doi.org/10.1016/j.mpsur.2009.04.015>
 47. Thim T, Karup NH, Grove EL, Rohde CV, Løfgren B. Initial assessment and treatment with the Airway , Breathing , Circulation , Disability , Exposure (ABCDE) approach. *International Journal of General Medicine.* 2012;5:117–121. <https://doi.org/10.2147/ijgm.s28478>
 48. Oteir AO, Ehs MS, Smith K, Grad H, Exec C, Grad BA, et al. The Prehospital Management of Suspected Spinal Cord Injury : An Update. *Prehospital and Disaster Medicine.*2014;29(4):399-402. <https://doi.org/10.1017/S1049023X14000752>
 49. Idowu OK, Yinusa W, Gbadegesin SA, Adebule GT. Risk factors for pressure ulceration in a resource constrained spinal injury service. *Spinal Cord.* 2011;49(5):643–7. <https://doi.org/10.1038/sc.2010.175>
 50. Nathens AB, Brunet FP, Maier RV. Development of trauma systems and effect on outcomes after injury. *Lancet.* 2004;363(9423):1794–801. [https://doi.org/10.1016/s0140-6736\(04\)16307-1](https://doi.org/10.1016/s0140-6736(04)16307-1)
 51. El Sayed MJ. Measuring Quality in Emergency Medical Services: A Review of

- Clinical Performance Indicators. *Emerg Med Int.* 2011;2012:1–7.
<https://doi.org/10.1155/2012/161630>
52. Yoganandan N, Arun MW, Stemper BD, Pintar FA, Maiman DJ. Biomechanics of human thoracolumbar spinal column trauma from vertical impact loading. *Ann Adv Automot Med.* 2013;57:155-66. PMID: 24406955; PMCID: PMC3861829.
 53. Yoganandan N, Stemper BD, Pintar FA, Maiman DJ, Mcentire BJ, Carol V. Clinical Biomechanics Cervical spine injury biomechanics: Applications for under body blast loadings in military environments. *JCLB.* 2013;28(6):602–9.
<http://dx.doi.org/10.1016/j.clinbiomech.2013.05.007>
 54. Looby S, Flanders A. Spine Trauma. *Radiol Clin NA.* 2011;49(1):129–63.
<http://dx.doi.org/10.1016/j.rcl.2010.07.019>
 55. Sekhon LHS, Fehlings MG, Frcs C. Epidemiology , Demographics , and Pathophysiology of Acute Spinal Cord Injury. *SPINE.* 2001;26(24):2–12.
 56. Merchant A, Outhay M, González-Calvo L, Moon TD et al. Training Laypersons and Hospital Personnel in Basic Resuscitation Techniques : an Approach to Impact the Global Trauma Burden in Mozambique. *World Journal of Surgery.* 2015;39:1433–1437. <https://doi.org/10.1007/s00268-015-2966-z>
 57. White CC, Domeier RM, Millin MG, Standards and Clinical Practice Committee NA of E physicians. 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. *Prehospital Emerg Care.* 2014;3127.
<https://doi.org/10.3109/10903127.2014.884197>
 58. Morrissey J. Research Suggests Time for Change in Prehospital Spinal Immobilization. *J Emerg Med Serv.* 2013;3(38).
 59. Benger J, Blackham J. Why Do We Put Cervical Collars On Conscious Trauma Patients? *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine.* 2009;4:1–4. <https://doi.org/10.1186/1757-7241-17-44>

60. Harrington DT, Connolly M, Biffi WL, Majercik SD, Cioffi WG. Transfer Times to Definitive Care Facilities Are Too Long A Consequence of an Immature Trauma System. *Annals of Surgery*. 2005;241(6):961–968.
<https://doi.org/10.1097/01.sla.0000164178.62726.f1>
61. Domeier RM, Arbor A, Welch K. Prospective Performance Assessment of an Out-of-Hospital Protocol for Selective Spine Immobilization Using Clinical Spine Clearance Criteria. *Annals of Emergency Medicine*. 2005;46(2):123–131.
<https://doi.org/10.1016/j.annemergmed.2005.02.004>
62. March JA, Ausband SC, Brown LH, March JA, Ausband SC, Hanges LHBC. Changes in the physical examination caused by use of spinal immobilization. *Prehospital Emerg Care*. 2002;6:421–424.
<https://doi.org/10.1080/10903120290938067>
63. Burton JH, Harmon NR, Dunn MG, Bradshaw JR, Burton JH, Harmon NR, et al. EMS Provider Findings and Interventions with a Statewide EMS Spine-Assessment Protocol. *Prehospital Emergency Care*. 2005;9(3): 303-309.
<https://doi.org/10.1080/10903120590962003>
64. Vaillancourt C, Stiell IG, Beaudoin T, Maloney J, Anton AR, et al. The Out-of-Hospital Validation of the Canadian C-Spine Rule by Paramedics. *Annals of emergency Medicine*. 2009;54(5):663-671.e1.
[DOI:10.1016/j.annemergmed.2009.03.008](https://doi.org/10.1016/j.annemergmed.2009.03.008)

Available from: <http://dx.doi.org/10.1016/j.annemergmed.2009.03.008>

65. Kanwaar R, Delasobera B, Hudson K, Frohna W. Emergency Department Evaluation and Treatment of Cervical Spine Injuries. *Emerg Med Clin*. 2015;33(2):241–82. <https://doi.org/10.1016/j.annemergmed.2009.03.008>
66. Peetz, A.B., Salim, A. Clearance of the Spine. *Curr Trauma Rep* 1, 160–168 (2015). <https://doi.org/10.1007/s40719-015-0019-6>
67. Mower WR, Hoffman J. Comparison of the Canadian C-Spine rule and NEXUS decision instrument in evaluating blunt trauma patients for cervical spine injury.

- Ann Emerg Med.* 2004;43(4):515–7.
<https://doi.org/10.1016/j.annemergmed.2003.12.005>
68. Inaba K, Dubose JJ, Barmparas G, Barbarino R, Reddy S, Talving P, et al. Clinical Examination Is Insufficient to Rule Out Thoracolumbar. *The Journal of Trauma Injury, Infection, and Critical Care.*2011;70(1):174-179.
<https://doi.org/10.1097/ta.0b013e3181d3cc6e>
 69. Joseph C, Delcarme A, Vlok I, Wahman K, Phillips J, Nilsson Wikmar L. Incidence and aetiology of traumatic spinal cord injury in Cape Town, South Africa: A prospective, population-based study. *Spinal Cord.* 2015;53(9):692–6.
<http://dx.doi.org/10.1038/sc.2015.51>
 70. Löfvenmark I., Norrbrink C, Nilsson-Wikmar L. et al. Traumatic spinal cord injury in Botswana: characteristics, aetiology and mortality. *Spinal Cord* 53, 150–154 (2015). <https://doi.org/10.1038/sc.2014.203>
 71. Mcdonald NE, Curran-sills G, Thomas RE. Outcomes and characteristics of non-immobilised , spine-injured trauma patients : a systematic review of prehospital selective immobilisation protocols. *Emerg Med J.* 2016;33:732-740.
<https://doi.org/10.1136/emered-2015-204693>
 72. Brown LH, Gough JE, Simonds WB. Can ems providers adequately assess trauma patients for cervical spinal injury ?. *Prehospital Emergency Care.*1997;2(1):33-36.
<https://doi.org/10.1080/10903129808958837>
 73. Woolf SH. The Meaning of Translational Research and Why It Matters. *J Am Med Assoc.* 2008;299(2):211–3. DOI:10.1001/jama.2007.26
 74. Lau R, Stevenson F, Ong BN, Dziedzic K, Treweek S, Eldridge S, et al. Achieving change in primary care — causes of the evidence to practice gap : systematic reviews of reviews. *Implement Sci.* 2016;11(40):1-39.
<http://dx.doi.org/10.1186/s13012-016-0396-4>
 75. Sutherland K, Levesque JF. Unwarranted clinical variation in health care : Definitions and proposal of an analytic framework. *Journal of Evaluation in Clinical*

Practice.2020;26:687-696. <https://doi.org/10.1111/jep.13181>

76. Munn Z, Peters MD, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol*. 2018; 18(1): 143. <https://doi.org/10.1186/s12874-018-0611-x>

Part B: Manuscript in Article Format

Title Page

Factors which affect the application and implementation of a spinal motion restriction protocol by prehospital providers in low resource settings: a scoping review

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Abstract

The South African Professional Board for Emergency Care prehospital Clinical Practice Guideline (CPG) recommends that emergency medical services (EMS) make use of the National Emergency X Radiography Utilization Study (NEXUS) rule and Canadian C-spine Rule (CCSR) when managing traumatic spinal injury. However, the safety and effectiveness of prehospital clinical spinal clearance or spinal motion restriction (SMR) decision support tools within poorly resourced settings are unclear. We conducted a scoping review on clinical spinal clearance and selective SMR decision support tools which aimed at identifying possible barriers to their implementation, safety, and effectiveness when used by EMS personnel. Studies were included if they described the use of clinical spinal clearance or SMR decision tools in first line management of blunt trauma patients by medical practitioners in the Emergency Department (ED) or by EMS personnel working in a prehospital setting. After screening, 42 documents fulfilled the inclusion criteria. Several selective SMR decision support tools have been implemented in the prehospital setting, the most common of which were those based on the NEXUS and the CCSR tools. Only one study evaluated the safety and efficacy of the NEXUS rule when used by EMS personnel. The limited prehospital literature available investigating either the NEXUS rule or CCSR therefore makes it difficult to determine its appropriateness for adoption and implementation by EMS personnel in other prehospital settings such as that of South Africa. Furthermore, commonly found prehospital NEXUS-based decision tools presented with unique challenges related to the subjective nature of some of the individual components of the decision tool. This leaves the decision tool open to interpretation by examiners and is especially relevant in settings, such as South Africa, where there are many different levels in scope of practices. This increases the risk of the patient being either under-triaged or over-triaged. More studies are therefore needed to definitively assess for the safety, efficacy and effectiveness of clinical spine clearance within the prehospital setting. It is believed that a selective SMR decision tool which has more specific instructions for the prehospital practitioner may be able to accommodate such challenges and is an area which needs further investigation.

Keywords: spinal immobilization; spinal motion restriction; spinal cord injuries; cervical spine

INTRODUCTION

Physical trauma is an injury to the body produced from impact, violence, or accident and is an omnipresent emergency commonly encountered within healthcare settings across the globe (1). Traumatic spinal injury (TSI) is a broadly defined term that considers injury to bony, ligamentous, and or neurologic structures of the spinal column (2). Thus, spinal cord injury or nerve root injury is a recognized complication of spinal trauma (3), commonly defined as traumatic spinal cord injury (TSCI).

International published literature suggests that the prevalence of TSCI after blunt trauma is low (3-25%) (4). Where a review indicates that epidemiologically, 55% of all spinal lesions are cervical, 15% thoracic, 15% thoracolumbar and 15% lumbosacral, the most common being C4-C5-C6, T4- T5 and T12-L1 (5). Furthermore, researchers such as Chiu et al. highlight differences in the respective reporting of the incidence rates of TSCI between that of developing and those of developed countries (6). These variations might be influenced by underreporting and or underdiagnosis of cases with TSCI, which may also include increased numbers of patients who may have died on scene due to potential inappropriate handling, triage and transportation (6). No matter the setting and the respective prevalence of TSCI, unrecognized injury to the cervical spine can cause catastrophic neurological disability, and therefore forms part of the initial prehospital management work up of the trauma patient (7). Therefore, the patient outcome may be directly influenced by Emergency Medical Service (EMS) personnel's ability to accurately diagnose a potential TSCI during such workup (7).

Historically it was thought that differentiating between patients with cervical spine injury and those without could not be reliably carried out by prehospital EMS personnel (8). This conventional thinking resulted in field protocols incorporating a conservative, non-selective approach to spinal immobilization in trauma patients. Recently, concern has been raised regarding the scientific merit of traditional EMS spinal immobilization practices, using cervical collars, headblocks, long spine board and spider harness (9). Amongst others, it has been suggested that spinal immobilization is

unnecessarily performed due to inappropriate patient selection and the low risk of spinal cord injury post-trauma, leading to the over-immobilization of patients (9–13). Several potential dangers and sequelae of spinal immobilization have also been reported and fall into four categories: increased pain, tissue breakdown, respiratory compromise, and ineffective motion restriction (14). It is believed that these adverse events may far outweigh the presumed benefits. Moreover, recent literature has suggested the abandonment of the term ‘spinal immobilization’ since complete non-movement of the spine is near impossible to achieve, thereby supporting the use of the term spinal motion restriction (SMR), as it is more descriptive of the desired objective (10,15).

Recent literature has purported that EMS personnel’s diagnostic ability can be improved through adopting a more selective approach to prehospital SMR (7). This notion receives support in light of recent studies that have demonstrated the safety and effectiveness of using a selective SMR decision support tool (4). Several benefits are proposed for the adoption of such tools by EMS personnel, including decreased costs to the patient and the health care system (16), minimizing patient discomfort and associated complications arising from the cervical spine (C-spine) motion restriction (16), decreased prehospital time (17), decreased rates of over-immobilization, and finally, the means to facilitate a more streamlined approach to the use of valuable resources in resource-constrained settings (10). As a result, there may be even more reason to include such decision tools for EMS operating in resourced constrained settings.

It should be noted that most of the benefits described above were based on research conducted in emergency departments (ED) in well-resourced settings (18-24). As a result, the safety and efficacy findings may not be generalizable to more resource-constrained settings. Furthermore, the prehospital environment presents unique challenges compared to secondary care environments (9). As an example, South Africa is an upper-middle-income country with several resource-constrained provincial EMS systems, each having a diverse landscape in terms of EMS staffing, knowledge and scope of practice. The Health Professions Council of South Africa (HPCSA) Professional Board for Emergency Care (PBEC) suggested in the 2018 Clinical Practice Guidelines (CPG) (25) that EMS make use of either the Canadian C-spine Rule (CCSR) (26) or National Emergency X Radiography Utilization Study (NEXUS) criteria (27) as selective SMR decision support tools.

These decision tools are clinical spinal clearance tools that originated from high-income countries (HICs) and have been validated in the in-hospital setting by specialist trauma physicians (26, 27).

Identifying system-specific barriers to and facilitators of selective SMR decision support tool adoption by EMS practitioners is important for developing appropriate adoption and implementation plans (28). Considering this, the authors sought to identify what these barriers and facilitators were by using a scoping review. In this instance, a scoping review was more beneficial than a systematic review, as selective SMR decision support tool adoption by EMS personnel is still a new concept, more so in resource-limited settings. Scoping reviews are useful when it is still unclear as to what other, specific questions can be posed and valuably addressed by a more precise systematic review as suggested by Munn et al. (28). Munn et al. (28) further suggest several other purposes for conducting scoping reviews, to which our scoping review draws on four of the listed purposes, including:

- Identifying types of available evidence on selective SMR decision support tools by EMS personnel
- Clarifying key concepts and definitions in the literature on selective SMR decision support tools, and that of clinical spinal clearance decision tools
- Examining how such research was conducted
- Identifying key characteristics or factors related to selective SMR decision support tools, and
- Identifying and analyzing the knowledge gaps around the topic.

Therefore, the overarching aim of this scoping review was to identify the published factors affecting the safe and effective application of selective SMR decision support tools used by EMS personnel on adult blunt trauma patients. These factors were further contextualized for the poorly resourced setting.

METHODS

This scoping review identifies and describes published literature on factors affecting the safe and effective application of selective SMR decision support tools used by EMS personnel on adult blunt trauma patients. An SMR decision support tool was defined as any protocol or algorithm consisting of predetermined clinical criteria or checklists that are used by ED staff or EMS personnel in the prehospital setting to clear the spine and inform their SMR practice clinically. This definition, therefore, excludes imaging modalities and clinical judgement.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Review checklist (Appendix 1) and the Arksey and O'Malley methodological framework, which suggest six stages for undertaking scoping reviews, were used to structure this report (29, 30).

Identifying the research question

In this scoping review, we sought to answer the following questions:

- Which selective SMR decision support tools have been implemented and/or evaluated in the prehospital setting for use by EMS practitioners?
- What are the potential barriers and facilitators that EMS practitioners may encounter in applying selective SMR decision support tools?
- What are the potential adverse events associated with using selective SMR decision support tools by EMS personnel?
-

Search strategy and information sources

The Medline (via PubMed), Embase Cochrane, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Web of Science, Turning Research Into Practice (TRIP) and EBSCO host online databases were searched in February 2021 using the following advanced search string in the first instance:

- (((emergency responders) OR (emergency care practitioner) OR (emergency medical technicians) OR (emergency medical services) OR (EMS) OR (prehospital) OR (out-of-hospital) OR ("out of hospital") OR (ambulances) OR (paramedic)) AND (((cervical) OR (c-spine) OR (spinal injury)) NOT (cancer)) AND ((clearance) OR (protocol) OR (algorithm) OR (rule) OR (triage) OR (NEXUS) OR (Canadian C-spine)))) AND (trauma) AND (2000:2021[pdat])

No search limitations were placed on the study design. Search results were limited to those published in or after 2000. During the review of full-text articles, the reference lists were examined for further articles potentially meeting the search criteria and these were screened against the established inclusion and exclusion criteria (Figure 1).

Screening and eligibility

Articles for which the full text was not available in English were excluded. Studies were eligible for inclusion if they described the use of any clinical spinal clearance decision tools in the first line management of blunt trauma patients by medical practitioners in the ED or by EMS personnel working in a prehospital setting in any country. Studies that focused only on helicopter EMS (HEMS) settings were excluded as the population served by HEMS is unique from that of other environments (31). Similarly, studies that focused only on interfacility transfer of patients were excluded. This review included only studies describing the care of adult blunt trauma patients as the pediatric age group may provide several challenges to the practice of immobilization and the assessment of injury to the neck in particular (32, 33). These are attributed to the unique anatomical, physiological and development characteristics that the pediatric patient group present (32,33). The age cut-off for management as an adult patient was determined by the clinical setting of the study under review. Studies describing patients who sustained penetrating injuries were excluded since SMR may have minimal benefits in treating these injuries which are unlikely to cause instability (34), may be associated with higher mortality (35, 36) and may increase the risk of deterioration (37).

Article titles and abstracts were screened against the eligibility criteria by one author and duplicate articles were removed. A second author confirmed the initial screening and conflicts were resolved by the third author. Following this initial screening, the full text of articles identified in the first screening step was reviewed and screened against the inclusion and exclusion criteria described above (Figure 1).

Extracting and charting the data

Data were charted according to a descriptive analytical framework, recommended by Arksey and O'Malley, modified to fit the aim of this review (30). The following data were extracted from each paper: Research Methods/study design; Intervention type and comparator (if any); Aim of the study; Study sample; Study context: prehospital / ED; Study outcomes; Country where the study was conducted.

The process of thematic data analysis as described by Levac, Colquhoun and O'Brien were then applied (38). This thematic data analysis describes general characteristics such as types of decision support tools used, study samples and contexts, as well as substantive issues directly related to the aim of this scoping review.

RESULTS

Forty-two articles were identified and included in this scoping review (Supplementary Table 1). The included articles were made up of consensus and opinion reports (n=6), case studies (n=1), retrospective chart reviews (n=8), reviews (n=10), prospective cohort studies (n=7), surveys and questionnaires (n=4), observational studies, including cross-sectional designs (n=4), retrospective descriptive study (n=1), and finally a practice improvement project (n=1). No experimental study designs were identified in the articles included in this review. Furthermore, only twenty-seven

articles (65%) included in this review gave an indication to the setting. The distribution of studies according to country were as follows: United States of America $n=15$, Canada $n=4$, Australia $n=2$, Ireland $n=1$, Europe $n=1$, United Kingdom $n=1$, Netherlands $n=1$, Germany $n=1$, and Scotland $n=1$. Of note, no studies were from low resourced settings.

Types of SMR decision support tools

Of the 42 articles included in this study, twenty-four articles (57%) focused on evaluating the use of specific SMR decision support tools (7,16,17,21,24, 39-57), three articles (7%) evaluated the attitude, knowledge and skill level of healthcare practitioners about SMR decision making (22, 58, 59), and the remainder of the articles make recommendations on the requirements for EMS personnel to effectively and safely clear the spine (9,10,15,18,20,34,36, 60-67).

Of the 24 articles evaluating specific SMR decision support tools, two studies (8%) evaluated the safety and effectiveness of using the National Emergency X Radiography Utilization Study (NEXUS) criteria. Both of these described its use in the hospital setting (43, 57). Three studies (13%) evaluated the Canadian C-spine Rule (CCSR); one of these was conducted in the prehospital setting (24, 50, 52). Two studies (8%) evaluated the effectiveness and safety of combining NEXUS-based criteria with some CCSR criteria elements, one of which was conducted in the prehospital setting (17, 44). Six studies (25%) evaluated the use of NEXUS-based protocols; all of these studies involved EMS personnel (16, 21, 46-48, 53). The remainder (46%) identified other SMR decision making criteria developed from consensus meetings and published systematic reviews (7, 39-42, 45, 49, 51, 54-56). Due to the limited number of studies evaluating the use of either NEXUS or CCSR decision support tools in the prehospital setting, the safety and effectiveness of implementing these specific decision tools in the prehospital setting are unclear (62).

Terminology

In conducting this scoping review, the authors identified that 12 articles (29%) used the term “clinical cervical spine clearance criteria” to define the type of spinal precaution decision support tool in use (16, 17, 24, 40, 43, 52, 57- 60, 62, 66) and 20 articles (47%) used the term “selective spinal motion restriction criteria” to define the type of spinal precaution decision support tool in use (7, 9, 10, 15, 18, 21, 39, 42, 45-47, 49, 51, 53-56, 61, 63, 67). A distinction between the terms used within the remainder of the articles (24%) could not be reached as there were either interchangeable use of the terms within the same article or no specific term was made use of (20, 22, 34, 36, 41, 44, 48, 50, 64, 65). Furthermore, 18 articles (43%) used the term protocol to define the criteria-based tool (18, 21, 39, 40-42, 45-49, 51, 54-56, 58, 61, 63), four articles (10%) used the term algorithm (9, 17, 24, 36), and eight articles (19%) made interchangeable use of algorithm and protocol (16, 20-22, 41, 42, 45, 67). The remainder of the articles only referenced these criteria as clinical assessment or decision criteria.

Facilitators and barriers related to the use of SMR decision tools

A total of 25 articles (60%) described potential facilitators to the use and effectiveness of SMR decision support tools (7, 10, 15, 17, 18, 20-22, 24, 36, 40, 42, 44, 51-54, 56, 58-60, 63, 64, 66, 67) and 23 articles (55%) described potential barriers to the use and effectiveness of SMR decision support tools (16, 18, 24, 39, 40, 44-46, 48-53, 56-60, 64-67).

DISCUSSION

This scoping review aimed to identify the published literature describing the type of selective SMR decision support tools currently in use in the prehospital setting and to identify the potential barriers and facilitators influencing the safe and effective implementation of these tools in low resource prehospital settings. Limited published literature that specifically evaluates the effectiveness of prehospital personnel utilization of the CCSR and NEXUS decision tools were

found. Therefore, the authors contextualized the findings of ED-based studies to the prehospital setting to highlight and discuss the reviews objective points. Several potential facilitators of and barriers to the effectiveness of SMR decision support tools, when used by EMS personnel, were identified and categorized thematically. The most prevalent themes are outlined and briefly discussed below.

Terminology

In reviewing the included literature, two key issues related to terminology were identified as potential barriers to use in the prehospital setting. The use of terms ‘clinical spine clearance’ and ‘selective spinal motion restriction’ were often used interchangeably (34). Whilst Hauswald and Braude (61) suggest that the difference between these two terms is uncertain, Quinn et al. (68) state that ‘clearing the spine’ is more vernacular than academic, and as a result, may have different intended meanings dependent on the circumstances and training level of the provider.

In reviewing the literature for this scoping review, based on the principle that the CCSR and NEXUS decision tools were developed to facilitate selective cervical spine radiography and expedite exclusion of cervical injury in patients in the hospital setting (26, 27, 57). The authors found it appropriate to classify these decision tools as clinical cervical spine clearance tools. In comparison, a selective SMR decision tool can be defined as a selective approach to the use of various SMR methods, which among others, include that of manual in-line stabilization or that of full-motion restriction (63), in the management work up, packaging, extrication and transportation of patients (55). Importantly the authors note that selective SMR decision making is facilitated by applying specific low-risk clinical criteria, which leads to the selective exclusion of patients from full-motion restriction (56). Thereby reducing the rate of unwarranted SMR and minimizing the reported adverse effects and harms associated with SMR equipment (34, 70-73). This decision tool can be considered as one which is patient-centered in the prehospital setting.

With this distinction in mind, this scoping review found only one study that examined the implementation of a clinical c-spine clearance tool, the CCSR, in the prehospital setting (50). The remainder of the articles examined only clinical cervical spine clearance tools' effectiveness when used by other ED staff (24, 43, 52, 57). Because of the limited availability of supporting studies examining the use of thereof in the prehospital setting and the fact that the skillset of EMS personnel varies by region (39), it is unclear whether clinical c-spine clearance tools can be effectively implemented in the poorly resourced prehospital setting.

Moreover, an important difference between the two terms and the context of use should be considered since one of the documented adverse events and barriers to using spine assessment decision tools is over-immobilization. This stems from the fear of legal litigation in the event of missing a serious injury (unstable fracture) (21, 44, 59). This distinction may be a useful mechanism to provide ethical and legal protection for the healthcare practitioner when completing patient report documentation (PRD), as clearing the spine cannot indisputably be achieved in the prehospital setting.

Lack of guideline compliance

Lack of assessment or guideline compliance was viewed as a general adverse event that often resulted in missed injury (16, 18, 24, 39, 40, 44-46, 48, 49, 51-53, 56, 58-60, 65, 66) was attributed to several different barriers, including missing or sporadic documentation and reporting on the decision for or against SMR (44, 45). EMS implementation strategies and plans might find value in incorporating ways to avoid the adverse events stemming from this barrier. Since missing information on PRD will cause further challenges in quality assurance measures such as monitoring the rate of compliance to SMR guidelines (51) and may also have legal ramifications (58).

Protocol misapplication where criteria were present, but no SMR was attempted by EMS (50, 51, 67) also contributed to the theme of noncompliance. This may be attributed to poor general applicability of the decision tool by EMS as criteria definitions were interpreted differently (39, 44, 46, 49-51, 53, 64).

Paramedics were also more conservative than their emergency physician counterparts in applying criteria, which often led to the adverse event of over-immobilization (16, 64). This practice increases the possibility of creating false-positive cases by the time the patient arrives at the hospital (56). Two main contributing factors can be attributed to this barrier; first, providers fear missing injuries and litigation (24, 44, 52, 59). Second, providers discomfort in performing a criterion such as asking the patient to rotate their neck (24, 50). The latter may be further attributed to provider doubts about the scientific merit of an SMR decision support tool and their subsequent apprehension about its application in clinical practice (24).

Patient-centered selective SMR algorithm to minimize harms associated with SMR devices

Published literature suggests the development and implementation of a selective SMR guideline that is directed at patient-centered outcomes which in so doing, may guide the tailored use of equipment (15, 17, 20, 22, 36, 44, 54, 56, 61, 67). This decision tool will not only aid in minimizing immobilization delays in the otherwise time critically ill patient and reduce the often-unnecessary exposure of patients to the risks associated with immobilization. Moreover, such an SMR tool may provide a standardized approach to providers, minimize provider variability, and facilitate guideline compliance monitoring (18, 22, 58). This was seen as an important facilitator to the effectiveness of SMR decision support tools.

Well-established and comprehensive implementation approach based on behavioral change theory.

When introducing new decision tools within the prehospital emergency care environment, the strategies used to implement them into regular practice are crucial to facilitate its effectiveness. Published literature highlights the need for purposeful directives to change institutional culture and mindset before the implementation approach. Thereby, recommending an implementation strategy based on behavioral change theory (44, 58), which can be achieved by conducting specific surveys on local attitudes and behavior (24, 40, 52, 59, 64). There is also the need for a well-established, comprehensive and multifaceted implementation strategy (24, 44, 56, 66). A well-established and comprehensive implementation approach may increase provider adherence and success of SMR decision tools and subsequently decrease the rate of over immobilization (40).

Implementation of selective motion restriction decision-making tools and clinical spine clearance protocols in the prehospital setting

Although several protocols that allow for selective SMR practice have been implemented in the prehospital environment, literature that specifically investigates the effectiveness and safety of spinal clearance in the prehospital setting is limited (62) and often inconsistent in poorly resourced settings. The safety of such protocols depends critically on the accuracy and appropriateness of their application (71).

In South Africa, the HPCSA PBEC has endorsed using the NEXUS criteria or CCSR by EMS providers (25). In the literature included in this review, these clinical spine clearance protocols have been validated in the ED setting (26, 27, 72, 73). Only Vaillancourt et al. (50) examined the adoption and use of the CCSR in the prehospital setting. In addition, the Norwegian guidelines for prehospital management of adult trauma patients with potential spinal injury only recommend the use of the NEXUS criteria (20). This recommendation was based on facility-based evidence, suggesting that the CCSR emphasizes the mechanism of injury (MOI), resulting in over-triage without increasing accuracy (74). Furthermore, it is to be noted that this guideline recommendation

was in the form of a consensus report, and no studies examining the safety, effectiveness and appropriateness of application were reported after its adoption. A blanket approach to spinal precautions within the prehospital setting may be challenging, especially in a setting such as South Africa, where the EMS qualification landscape is very diverse. The variability in skills and knowledge may be a confounding factor (71) when extrapolating results from other settings.

Considerations in the prehospital application of the NEXUS criteria and CCSR

Considering the HPCSA PBEC recommendation of the use of either NEXUS or CCSR (25), we found it relevant to investigate the skill and knowledge level needed for the appropriate, safe and effective application of the respective criteria as it may lead to missed injuries (75).

The NEXUS protocol identifies five low-risk criteria to be present for the patient to be classified as having a low risk of injury (27), and therefore indicating those patients who do not need SMR or imaging:

1. No midline cervical tenderness on direct palpation
2. No focal neurological deficit
3. Normal alertness
4. No intoxication
5. No painful distracting injuries

Similarly, the CCSR (26) seeks to identify patients at high risk of having sustained a possible TSCI and would therefore require further diagnostic imaging or SMR. These criteria incorporate the patient's age, MOI, and clinical status upon assessment.

Literature highlights that the effectiveness of these prediction tools is reliant on the operator's understanding of the anatomy and physiology of the cervical spine, their ability to take an adequate history, recognize the importance of the MOI, and perform an adequate evaluation of the patient to ensure that nothing is missed (76). The respective education and experience of the practitioner are therefore important. The effectiveness and safety of applying the NEXUS rule have been examined across several disciplinary levels, where some concerns were documented (60). The greatest concern is that the individual components introduce substantial subjectivity to the rule (60, 77). As a result, the interpretation is subject to variability (73). Interestingly, literature states that ED personnel often resist prehospital clearance by EMS practitioners because of several unresolved issues (62), one of which is the subjective interpretation, and therefore lack of standardization in criteria evaluation. This resistance remains even though the spine's clinical clearance criteria are continually being refined (62):

Since no studies investigating the use of NEXUS criteria by EMS were found, we refer to a few instances where the subjective nature of the NEXUS criteria was found challenging in informing appropriate evaluation and care in the ED. Firstly, it needs to be noted that the NEXUS criteria and CCSR were developed for the management and clearance of fully conscious trauma patients, not the confused or comatose patients (78). It is therefore important that the EMS practitioner appropriately distinguishes between the alert and altered alert state. In the original NEXUS criteria, altered alertness was defined as patients having a Glasgow Coma Scale (GCS) of 14 or less (79). However, in some studies, altered alertness was replaced with "evaluable patients", and patients with a GCS as low as 13 were cleared NEXUS negative (77). Examiners of different expertise, backgrounds and levels of experience may interpret these criteria differently (60). Therefore, suggestions are made to clarify the definition of mental status to positively impact the reliability of the tool when used (60). This is especially relevant when managing the geriatric patient

population. Using specific GCS criteria to determine the altered alert state in this patient group may have direct implications for their management, as many of these patients may have some baseline level of cognitive impairment (77). Therefore, these patients may present with a GCS <15 but will be in their baseline mental status (77). As a result, there is a reluctance to accept the reliability of the NEXUS criteria when used in this group of patients.

One observational study conducted in a military ED compared the interrater agreement of NEXUS criteria between a faculty physician and a resident (75). Low and fair levels of agreement were found for the focal neurological deficit and altered mental status components, respectively. It was suggested that this could be attributed to the experience levels of the examiner. Additionally, the criteria for the presence of a distracting injury showed poor agreement; although the NEXUS provides examples of what may constitute a distracting injury, there is no precise definition for this (75). Because of the differences in scope, years of experience and training the examiner received, it was suggested that more explicit training, which included more simulated training and direct observations of examinations of patients, may narrow this disagreement (75). This is supported by a systematic review suggesting that the examiner's level of training and experience contributes to the reproducibility of the clinical prediction rules (60).

Similarly, the CCSR has specific challenges with the subjective nature of some of the criteria, such as the presence of distracting injuries, which is deemed unreliable (80). Another documented challenge in using CCSR concerns the difficulty of remembering the protocol and the complexity of its criteria when used in daily practice (81). As a result, most practitioners who are provided with an alternate decision tool such as the NEXUS may opt to use these criteria instead (81,82). With this in mind, a further challenge that may be encountered in prescribing two clinical spine clearance protocols for use in one setting is the non-adherence to the guideline as there may be an uncertainty of which guideline to follow, and it may create confusion between the two. This may also lead to a lack of standardization of reporting on examiner assessment and findings. Coggins et al. (44) performed a mixed-method study to investigate the current practices and rate of

concordance with established international guidelines by its ED personnel. According to the NEXUS Rule, this ED had two guideline recommendations in place, namely the CCSR and an in-patient trauma guideline. The findings of this study revealed a low level of guideline utilization and significant discrepancies in all cases present. One suggested explanation for the non-adherence to guidelines may be a lack of awareness of which guidelines to use (44). Therefore, it is important for the South African PBEC to consider that implementing a single guideline could serve as a facilitator in improving the care provided to TSCI patients by EMS personnel.

Finally, in the prehospital setting, assessing the criterion ‘presence of intoxication’ may be challenging. Different reviews (36, 39, 45, 56) highlight possible concerns, which raises whether this specific criterion should indeed form part of an SMR decision instrument. First, because alcohol or drug testing kits are not usually available (or may not be allowed), assessing this criterion is subjective, i.e., based on the practitioner’s judgement of signs of intoxication. This subjectivity may create barriers to the effective utilization of the decision instrument. In one retrospective chart review (45) that aimed to determine the characteristics of patients under-immobilized by prehospital providers, the researchers found that 5% of the patients who met the criteria for SMR were not immobilized by prehospital personnel. When the hospital reports were examined, most of the under immobilized group of patients had drug or alcohol intoxication. The authors of this study believed that a possible reason why EMS may have missed this criterion was that the patient appeared to have been sober upon initial assessment by EMS. However, it is to be noted that intoxication may also contribute to a patient being non-compliant or non-cooperative, thereby refusing SMR. Second, because clinical signs such as abnormal coordination and slurred speech are unreliable indicators of intoxication (83), it may be clinically difficult for EMS to differentiate between an intoxicated patient and one who has sustained other more critical injuries such as intracranial hemorrhage (36). For this reason, Maschaman et al. (36), in their development on guidelines for immobilization of adult patients by EMS in Denmark, recommended that patients affected by alcohol and drug intoxication should be treated like all other non-intoxicated patients; that is, intoxication should not be seen as a criterion to SMR. With these somewhat different notions in mind, we believe it is important that professional governing bodies should take cognizance of these factors when determining which criteria may work best for a particular setting.

Alternative prehospital SMR decision tools

Upon further examination of the literature, we observed that SMR decision tools that incorporate and modify the NEXUS criteria and CCSR are commonly found (7, 39). This modification may have been done to address the documented challenges when using the NEXUS and CCSR criteria and increase its sensitivity in the prehospital setting (7, 39). Many EMS settings make use of this process to develop their selective SMR decision tools and usually use a combination of extrapolating ED protocols designed to identify those patients who need imaging to clear or diagnose an injured spine, expert opinion, Advanced Trauma Life Support guidelines, and other smaller EMS related studies (51). Several studies have demonstrated that EMS practitioners can use simple guidelines to inform them of which patients can forgo motion restriction, i.e., those patients at low risk of clinically significant spinal injury (47, 51, 55, 61, 84)-

It should be noted that modified criteria used to increase sensitivity in the prehospital setting present documented challenges. In a 1998 observational study, Meldon et al. (71) aimed to evaluate the level of agreement for cervical spinal injury between the Emergency Medical Technician (EMT) and Emergency Physician (EP) when using an existing clinical spinal clearance protocol for the prehospital blunt trauma patient (71). This study used the NEXUS-based criteria of MOI consistent with a cervical spine injury, reliable mental status, distracting injury, neck pain or tenderness, neurological deficit, and neck pain with motion. The overall findings of interrater agreement between the two practitioners were poor. Moreover, the levels of agreement between the individual clearance criteria were also poor except for the assessment of mental status, which demonstrated fair to good agreement (71).

Several other studies have also questioned the reliability of cervical spine injury detection in the elderly population group (≥ 65 years) when using the NEXUS-based protocols, which incorporate a clinical assessment component with consideration for the MOI (54, 77). Because of the skeletal fragility of the older population (85), they are more often subject to cervical spine injury from

lower force MOI, such as ground-level falls, which would be considered NEXUS negative (77). Thus, older age should be considered an independent risk factor for cervical spine injury in blunt trauma (77) and is therefore considered a deficiency in the protocol. In many studies researching the EMS practitioners use of NEXUS-based protocols in the prehospital setting, such as a retrospective chart review by Stroh and Braud (51), this protocol deficiency has resulted in the under immobilization of geriatric patients with serious spinal injury, which should have been motion restricted (77, 86).

Considering the documented challenges and errors encountered with the clinical spine clearance protocols developed by modifying the NEXUS and CCSR criteria, the main question that arises is whether these protocols are appropriate for effectively guiding spinal practice in the EMS arena. More studies are needed to definitively assess the safety, efficacy and effectiveness of clinical spine clearance within the prehospital setting (69). It is believed that a selective SMR decision tool with more specific instructions for the prehospital practitioner to make use of may accommodate such challenges and is an area that needs further investigation.

Recommendations for future research

Prehospital SMR decision tools have the stated aim of reducing unnecessary motion restriction and its associated adverse effects while protecting patients with injuries from further harm (67). It is important to consider not only who requires treatment, but also which treatments are appropriate. Therefore, we considered how clinical decision tools could be improved for the prehospital setting (67).

Although the rate of spinal cord injury after blunt trauma is low (4), we cannot dispute that SMR is necessary for some trauma patients. Therefore, developing an appropriate spinal management strategy that incorporates criteria into a decision tool with more prehospital specific instructions

for selective SMR is of value. These instructions should specifically minimize patient harms associated with both over and under immobilization (61). This may be achieved through an SMR algorithm which provides the practitioner with different treatment considerations. More specifically, an algorithm that considers the setting, skills, and capability of EMS personnel and the availability of equipment and the patient condition will be of value in informing the EMS practitioners decision-making with regards to appropriate SMR.

There are a few studies that incorporated selective SMR decision making tools with these factors in mind. Interestingly, the Norwegian guidelines for prehospital management of the trauma patient (20), although in support of NEXUS use, suggested that SMR should not delay nor preclude in the critically injured patient life-saving interventions. It further suggests that in these instances, SMR should be de-emphasized. Another SMR algorithm used in Arizona (55), provides the practitioner with detailed information on what may constitute an unreliable patient, how to perform a motor or sensory examination, and SMR preferred packaging types for different evaluation outcomes. This is not a binary SMR decision tool. In addition, this algorithm emphasizes that life-threatening conditions and evacuation from imminent threat take priority over SMR (63). This may be relevant for the South African EMS, who are often dispatched to areas of high criminal activity, where real threats to the practitioner and patient are imminent.

Furthermore, the Emergency Medicine Spinal Immobilization Protocol developed for Germany's EMS is an algorithm that allows for variable decision-making regarding patient packaging methods, which are dependent on the condition and the injury pattern of the trauma patient (54). This algorithm guides three types of motion restriction practices: to establish motion restriction manually, the second is minimal motion restriction performed using only a cervical collar, and the third includes full-motion restriction using all devices. This algorithm may guide the management approach of the patient who has sustained multiple traumas. This algorithm is similar to the recommendations made by a consensus group that developed new national guidelines on spinal stabilization of adult patients for Denmark EMS through the Danish National Board of Health (36). They provided a useful example of an algorithm that incorporates motion restriction outcomes based on initial clinical findings, thereby guiding specific treatment options (36). These SMR

categories include i) No efforts of spinal stabilization, ii) spinal stabilization on a vacuum mattress, and iii) Time-critical spinal stabilization. However, it must be noted that there is no implementation study on the effectiveness of this algorithm available in English print. For the South African EMS landscape and other similar settings where there often exists a mismatch between the demand for emergency medical care and the resource capacity, an SMR decision algorithm which indicates alternative packaging options to the provider may be especially useful when the most appropriate SMR device is not readily available.

It may also be useful to incorporate additional factors into prehospital spinal assessments. A retrospective cohort study conducted in the state of Victoria, Australia (7) investigated predictors of TSCI additional to the NEXUS and CCSR criteria. This investigation found several easily detectable factors associated with confirmed TSCI, one being the Ambulance Victoria Potential Major Trauma Criteria. Encouraging other EMS to integrate similar trauma assessment criteria into their guidelines may improve accuracy in identifying TSCI. Although only validated for the in-hospital setting (87), many South African EMS practitioners already make use of the South African Triage Scale (SATS) (88). Since SMR research is limited in South Africa, this provides an opportunity to use the state of Victoria's research as a framework to guide future studies which investigate and identify prediction criteria other than that of the NEXUS and CCSR.

Lastly, although some literature suggests no relevance in a 'stand and take down' approach for use in patients walking on the scene (10) or refusing care, it is recommended that extreme caution be exercised, especially in those patients refusing cervical collar placement. A retrospective review conducted in Cedars-Sinai Medical Centre in the USA (89), made a strong argument that non-cooperative or non-compliant patients were most at risk of C-spine injury. Of the 16 confirmed cervical spine injury cases in this study, three were among the non-compliant group. Although this knowledge would most likely not change EMS practice as it would be very difficult persuading a non-cooperative patient, the importance of this information is that the practitioner would not assume that what appears as a stubborn, or otherwise stable, walking patient, is necessarily the case.

Strengths and limitations

This scoping review has several potential limitations. First studies published not published in English were excluded, and therefore important literature relevant to the topic may have been missed. Second, the search was limited to January 2000 – December 2020 with an updated search using the same search string completed in February 2021. Since this was not a systematic review or a meta-analysis the strength and validity of studies included in this scoping review was not determined.

CONCLUSION

This scoping review found limited, often inconsistent literature available investigating the effectiveness and safety of the CCSR or the NEXUS rule as a spinal clearance tool in the prehospital setting, especially in poorly resourced settings. SMR decision support tools that incorporate and modify the NEXUS rule and CCSR, on the other hand, were commonly found in use by prehospital personnel. This modification may have been done to address the documented challenges when using the NEXUS and CCSR criteria and increase its sensitivity in the prehospital setting. These NEXUS-based decision tools also present with their challenges to EMS personnel due to some of the subjective nature of the criteria. Therefore, more studies are needed to definitively assess for the safety, efficacy, and effectiveness of clinical spine clearance within the prehospital setting. It is believed that a selective SMR decision tool with more specific instructions for the prehospital practitioner to make use of may accommodate such challenges and is an area that needs further investigation.

Furthermore, several other factors have also been found which may impact the safety, and efficacy of the use of SMR decision tools in addition to the continuation of spinal care at a secondary level; however, only the prevalent themes have been addressed in this manuscript. These include

education, implementation and dissemination of guidelines (4), lack of protocol compliance and the standardization of patient report documentation when reporting on spinal evaluation findings, quality assurance in the form of clinical governance of spinal care practices, individual provider barriers and facilitators in the use of SMR decision tools, use of SMR during extrication procedures, and finally, the applicability of appropriate transportation decision making after identifying the high risk spinal injured patient in the prehospital setting.

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REFERENCES

1. David JS, Bouzat P, Raux M. Evolution and organisation of trauma systems. *Anaesth Crit Care Pain Med*. 2019 Apr;38(2):161-167. DOI: [10.1016/j.accpm.2018.01.006](https://doi.org/10.1016/j.accpm.2018.01.006). Epub 2018 Feb 21. PMID: 29476943.
2. Kumar R, Lim J, Mekary RA, Rattani A, Dewan MC, Sharif SY, et al. Traumatic Spinal Injury: Global Epidemiology and Worldwide Volume. *World Neurosurg*. 2018;113:e345–63. Available from: <https://doi.org/10.1016/j.wneu.2018.02.033>
3. Gummerson NW, Cole AA. Spinal fractures in adults. *Surgery*. 2009;27(7):287–91. Available from: <http://dx.doi.org/10.1016/j.mpsur.2009.04.015>
4. Theodore N, Hadley MN. Prehospital Cervical Spinal Immobilization After Trauma. 2013;72(3):22–34. <https://doi.org/10.1227/neu.0b013e318276edb1>
5. Cacho García S, Peña Otero D, Eguillor Mutiloa M. Efficacy of cervical immobilization in multiple trauma patients. *Int J Crit Care Emerg Med*. 2019;5(1): Art. #061. doi.org/10.23937/2474-3674/1510061
6. Chiu AW, Lin H, Lam C, Chu S, Chiang Y. Epidemiology of Traumatic Spinal Cord Injury: Developed and developing countries. *Asia-Pacific Journal of Public Health*. 2010;22(1):9-18. DOI: [10.1177/1010539509355470](https://doi.org/10.1177/1010539509355470)
7. Oteir AO, Smith K, Stoelwinder J, Middleton JW, Cox S, Sharwood LN, Jennings PA. Prehospital predictors of traumatic spinal cord injury in Victoria, Australia. *Prehosp Emerg Care*. 2017;21(5):583–590. <http://dx.doi.org/10.1080/10903127.2017.1308608>
8. Sochor M, Althoff S, Bose D, Maio R, Deflorio P. Glass intact assures safe cervical spine protocol. *J Emerg Med*. 2020;44(3):631–636.e1. <http://dx.doi.org/10.1016/j.jemermed.2012.07.076>
9. Connor D, Greaves I, Porter K, Bloch M. Pre-hospital spinal immobilisation: an initial consensus statement. *Emerg Med J*. 2013;30(12):1067–1069. <http://dx.doi.org/10.1136/emered-2013-203207>

10. Stanton D, Hardcastle T, Muhlbauer D, Van Zyl D. Cervical collars and immobilisation: a South African best practice recommendation. *Afr J Emerg Med.* 2017;7(1):4–8. <http://dx.doi.org/10.1016/j.afjem.2017.01.007>
11. Sundstrøm T, Asbjørnsen H, Habiba S, Sunde GA, Wester K. Prehospital use of cervical collars in trauma patients: a critical review. *J Neurotrauma.* 2014;31(6):531–540. <http://dx.doi.org/10.1089/neu.2013.3094>
12. Stuke LE, Pons PT, Guy JS, Chapleau WP, Butler FK, McSwain NE. Prehospital spine immobilization for penetrating trauma – review and recommendations from the Prehospital Trauma Life Support Executive Committee. *J Trauma.* 2011;71(3):763–770. DOI: [10.1097/TA.0b013e3182255cb9](http://dx.doi.org/10.1097/TA.0b013e3182255cb9)
13. Looby S, Flanders A. Spine trauma. *Radiol Clin North Am.* 2011;49(1):129–163. <http://dx.doi.org/10.1016/j.rcl.2010.07.019>
14. Feld FX. Removal of the long spine board from clinical practice: a historical perspective. *J Athl Train.* 2018;53(8):752–755. <http://dx.doi.org/10.4085/1062-6050-462-17>
15. Fischer P, Perina D, Delbridge T, Fallet M, Salomone J, Dodd J, Bulger EM, Gestring ML. Spinal motion restriction in the trauma patient – a joint position statement. *Prehosp Emerg Care.* 2018;22(6):659–661.
16. Gonzalez R, Cummings G, Baker J, Frotan A, Simmons J, Brevard S, Michon E, Harlan SM, Meyers DC, Rodning CB. Prehospital clinical clearance of the cervical spine: a prospective study. *Am Surg.* 2013;79(11):1213–1217. <http://dx.doi.org/10.1177/000313481307901128>
17. Armstrong B, Simpson H, Crouch R, Deakin C. Prehospital clearance of the cervical spine: does it need to be a pain in the neck? *Emerg Med J.* 2007;24(7):501–503. <http://dx.doi.org/10.1136/emj.2006.041897>
18. Larson S, Delnat AU, Moore J. The use of clinical cervical spine clearance in trauma patients: a literature review. *J Emerg Nurs.* 2018;44(4):368–374. <http://dx.doi.org/10.1016/j.jen.2017.10.013>
19. Vaillancourt C, Charette M, Kasaboski A, Maloney J, Wells GA, Stiell IG. Evaluation of the safety of C-spine clearance by paramedics: design and methodology. *BMC Emerg Med.* 2011;11: Art. #1. [Cited 26 February 2021]. Available from: <http://www.biomedcentral.com/1471-227X/11/1>

20. Kornhall DK, Jørgensen JJ, Brommeland T, Hyldmo PK, Asbjørnsen H, Dolven T, Hansen T, Jeppesen E. The Norwegian guidelines for the prehospital management of adult trauma patients with potential spinal injury. *Scand J Trauma Resusc Emerg Med*. 2017;25(2): Art. #2. <http://dx.doi.org/10.1186/s13049-016-0345-x>
21. Jin PFK, Goslings JC, Luitse J, Ponsen KJ. A retrospective study of five clinical criteria and one age criterion for selective prehospital spinal immobilization. *Eur J Trauma Emerg Surg*. 2007;33(4):401–407. <http://dx.doi.org/10.1007/s00068-007-6197-3>
22. Kreinest M, Goller S, Grützner BGPA, Häske MKD, Papathanassiou V, Münzberg M. Expertise of German paramedics concerning the prehospital treatment of patients with spinal trauma. *Eur J Trauma Emerg Surg*. 2017;43(3):371–376. <http://dx.doi.org/10.1007/s00068-016-0682-5>
23. Paykin G, Reilly GO, Ackland HM, Mitra B. The NEXUS criteria are insufficient to exclude cervical spine fractures in older blunt trauma patients. *Injury*. 2017;48(5):1020–1024. <http://dx.doi.org/10.1016/j.injury.2017.02.013>
24. Fontaine G, Forgione M, Lusignan F, Lanoue MA, Drouin S. Cervical spine collar removal by emergency room nurses: a quality improvement project. *J Emerg Nurs*. 2018;44(3):228–235. <http://dx.doi.org/10.1016/j.jen.2017.07.018>
25. Health Professions Council of South Africa (HPCSA). Professional Board of Emergency Care (PBEC) Clinical Practice Guideline. 2018. [Cited 26 February 2021]. Available from: <https://www.hpcsa.co.za/?contentId=0&menuSubId=45&actionName=Professional%20Boards>
26. Stiell IG, Wells GA, Vandemheen KL, Clement CM, Lesiuk H, De Maio VJ, Laupacis A, Schull M, McKnight RD, Verbeek R, et al. The Canadian C-spine rule for radiography in alert and stable trauma patients. *JAMA*. 2001;286(15):1841–1848. <http://dx.doi.org/10.1001/jama.286.15.1841>
27. Hoffman J, Mower W, Wolfson AB, Todd, KH, Zucker MI. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. *New Engl J Med*. 2000;343(2):94–99. <http://dx.doi.org/10.1056/NEJM200007133430203>
28. Munn Z, Peters MD, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping

- review approach. *BMC Med Res Methodol.* 2018; 18(1): 143.
<https://doi.org/10.1186/s12874-018-0611-x>
29. Tricco AC, Lillie E, Zarin W, Brien KKO, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med.* 2018;169(7):467–485.
<http://dx.doi.org/10.7326/M18-0850>
 30. Hilary Arksey & Lisa O'Malley (2005) Scoping studies: towards a methodological framework, *International Journal of Social Research Methodology*, 8:1, 19-32, DOI: [10.1080/1364557032000119616](https://doi.org/10.1080/1364557032000119616)
 31. Werman HA, White LJ, Herron H, Deppe S, Love L, Betz S, Santanello S. Clinical clearance of spinal immobilization in the air medical environment: a feasibility study. *J Trauma.* 2008;64(6):1539–1542. DOI: [10.1097/TA.0b013e31806911ba](https://doi.org/10.1097/TA.0b013e31806911ba)
 32. McCarthy C, Oakley E. Management of suspected cervical spine injuries – the paediatric perspective. *Accid Emerg Nurs.* 2002;10(3):163–169.
<http://dx.doi.org/10.1054/aaen.2002.0360>
 33. Browne GJ, Lam LT, Barker RA. The usefulness of a modified adult protocol for the clearance of paediatric cervical spine injury in the emergency department. *Emerg Med.* 2003;15(2):133–142. <http://dx.doi.org/10.1046/j.1442-2026.2003.00345.x>
 34. Oteir AO, Smith K, Jennings PA, Stoelwinder JU. The prehospital management of suspected spinal cord injury: an update. *Prehosp Disaster Med.* 2014;29(4):399–402.
<http://dx.doi.org/10.1017/S1049023X14000752>
 35. Haut ER, Kalish BT, Efron DT, Haider AH, Stevens KA, Kieninger AN, Cornwell EE 3rd, Chang DC. Spine immobilization in penetrating trauma: more harm than good? *J Trauma.* 2010;68(1):115–121. DOI: [10.1097/TA.0b013e3181c9ee58](https://doi.org/10.1097/TA.0b013e3181c9ee58)
 36. Maschmann C, Jeppesen E, Rubin MA, Barfod C. New clinical guidelines on the spinal stabilisation of adult trauma patients – consensus and evidence based. *Scand J Trauma Resusc Emerg Med.* 2019;27(1): Art. #77. DOI: [10.1186/s13049-019-0655-x](https://doi.org/10.1186/s13049-019-0655-x)
 37. Vanderlan WB, Tew BE, Seguin CY, Mata MM, Yang JJ, Horst HM, Obeid FN, McSwain NE. Neurologic sequelae of penetrating cervical trauma. *Spine.* 2009;34(24):2646–2653. <http://dx.doi.org/10.1097/BRS.0b013e3181bd9df1>

38. Levac, D., Colquhoun, H. & O'Brien, K.K. Scoping studies: advancing the methodology. *Implementation Sci* 5, 69 (2010). <https://doi.org/10.1186/1748-5908-5-69>.
39. Hong R, Meenan M, Prince E, Murphy R, Tambussi C, Rohrbach R, Baumann BM. Comparison of three prehospital cervical spine protocols for missed injuries. *West J Emerg Med*. 2014;15(4):471–479. <http://dx.doi.org/10.5811/westjem.2014.2.19244>
40. Sebastian R, Miller K, Langdorf M, Johnson D. EMS adherence to a pre-hospital cervical spine clearance protocol. *Cal J Emerg Med*. 2001;2(4):44–46. [Cited 27 February 2021]. Available from: <https://europepmc.org/article/med/20852696>
41. Tatum JM, Melo N, Ko A, Dhillon NK, Smith EJT, Yim DA, Barmparas G, Ley EJ. Validation of a field spinal motion restriction protocol in a level I trauma center. *J Surg Res*. 2017;211:223–227. <http://dx.doi.org/10.1016/j.jss.2016.12.030>
42. Underbrink L, Dalton AT, Leonard J, Bourg PW, Blackmore A, Valverde H, Candlin T 3rd, Caputo LM, Duran C, Peckham S, et al. New immobilization guidelines change EMS critical thinking in older adults with spine trauma. *Prehosp Emerg Care*. 2018;22(5):637–644. <http://dx.doi.org/10.1080/10903127.2017.1423138>
43. Pitt E, Pedley DK, Nelson A, Cumming M, Johnston M. Removal of C-spine protection by A&E triage nurses: a prospective trial of a clinical decision making instrument. *Emerg Med J*. 2006;23(3):214–215. <http://dx.doi.org/10.1136/emj.2005.023697>
44. Coggins A, Ebrahimi N, Kemp U, Shea KO, Fusi M, Murphy M. A prospective evaluation of cervical spine immobilisation in low-risk trauma patients at a tertiary emergency department. *Australas Emerg Care*. 2019;22(2):69–75. <http://dx.doi.org/10.1016/j.auec.2019.04.001>
45. Paterek E, Isenberg DL, Schiffer H. Characteristics of trauma patients with potential cervical spine injuries underimmobilized by prehospital providers. *Spine*. 2015;40(24):1898–1902. <http://dx.doi.org/10.1097/BRS.0000000000001149>
46. Burton J, Dunn M, Harmon N, Hermanson T, Bradshaw J. A statewide, prehospital emergency medical service selective patient spine immobilization protocol. *J Trauma*. 2006;61(1):161–167. <http://dx.doi.org/10.1097/01.ta.0000224214.72945.c4>
47. Burton JH, Harmon NR, Dunn MG, Bradshaw JR. EMS provider findings and interventions with a statewide EMS spine-assessment protocol. *Prehosp Emerg Care*. 2005;9(3):303–309. <http://dx.doi.org/10.1080/10903120590962003>

48. Domeier RM, Swor RA, Evans RW, Hancock JB, Fales W, Krohmer J, Frederiksen SM, Rivera-Rivera EJ, Schork MA. Multicenter prospective validation of prehospital clinical spinal clearance criteria. *J Trauma*. 2002;53(4):744–750.
<http://dx.doi.org/10.1097/00005373-200210000-00021>
49. Domeier M, Frederiksen SM, Welch K. Prospective performance assessment of an out-of-hospital protocol for selective spine immobilization using clinical spine clearance criteria. *Ann Emerg Med*. 2005;46(2):123–131.
<http://dx.doi.org/10.1016/j.annemergmed.2005.02.004>
50. Vaillancourt C, Stiell IG, Beaudoin T, Maloney J, Anton AR, Bradford P, Cain E, Travers A, Stempien M, Lees M, et al. The out-of-hospital validation of the Canadian C-spine rule by paramedics. *Ann Emerg Med*. 2009;54(5):663–671.
<http://dx.doi.org/10.1016/j.annemergmed.2009.03.008>
51. Stroh G, Braude D. Can an out-of-hospital cervical spine clearance protocol identify all patients with injuries? An argument for selective immobilization. *Ann Emerg Med*. 2001;37(6):609–615. <http://dx.doi.org/10.1067/mem.2001.114409>
52. Clement CM, Stiell IG, Lowe MA, Brehaut JC, Calder LA, Vaillancourt C, Perry JJ. Facilitators and barriers to application of the Canadian C-spine rule by emergency department triage nurses. *Int Emerg Nurs*. 2016;27:24–30.
<http://dx.doi.org/10.1016/j.ienj.2015.11.008>
53. Myers LA, Russi CS, Hankins DG, Berns KS, Zietlow SP. Efficacy and compliance of a prehospital spinal immobilization guideline. *Int J Emerg Med*. 2009;2(1):13–17.
<http://dx.doi.org/10.1007/s12245-009-0082-2>
54. Kreinest M, Gliwitzky B, Schüler S, Grützner PA, Münzberg M. Development of a new emergency medicine spinal immobilization protocol for trauma patients and a test of applicability by German emergency care providers. *Scand J Trauma Resusc Emerg Med*. 2016;24(7): Art. #71. <http://dx.doi.org/10.1186/s13049-016-0267-7>
55. Castro-Marin F, Gaither JB, Rice AD, Blust RN, Chikani V, Vossbrink A, Bobrow BJ. Prehospital protocols reducing long spinal board use are not associated with a change in incidence of spinal cord injury. *Prehospital Emerg Care*. 2020;24(3):401–410.
<http://dx.doi.org/10.1080/10903127.2019.1645923>

56. Dunn TM, Dalton A, Dorfman T, Dunn WW. Are emergency medical technician- basics able to use a selective immobilization of the cervical spine protocol? A preliminary report. *Prehosp Emerg Care*. 2004;8(2):207–211.
<http://dx.doi.org/10.1080/312703004374>
57. Collins NC, McKenzie JV. The NEXUS criteria: do they stand the test of time? *Eur J Emerg Med*. 2013;20(1):58–60. <http://dx.doi.org/10.1097/MEJ.0b013e32834fe94a>
58. Cardozo S, Angus LDG. Use of an electronic C-spine clearance strategy to ensure compliance with confrontational examinations. *J Trauma Nurs*. 2015;22(5):255–260.
<http://dx.doi.org/10.1097/JTN.0000000000000150>
59. Clement CM, Stiell IG, Davies B, O'Connor A, Brehaut JC, Sheehan P, Clavet T, Leclair C, MacKenzie T, Beland C. Perceived facilitators and barriers to clinical clearance of the cervical spine by emergency department nurses: a major step towards changing practice in the emergency department. *Int Emerg Nurs*. 2011;19(1):44–52.
<http://dx.doi.org/10.1016/j.ienj.2009.12.002>
60. Moser N, Lemeunier N, Southerst D, Shearer H, Murnaghan K, Sutton D, Côté P. Validity and reliability of clinical prediction rules used to screen for cervical spine injury in alert low- risk patients with blunt trauma to the neck: part 2. A systematic review from the Cervical Assessment and Diagnosis Research Evaluation (CADRE) Collaboration. *Eur Spine J*. 2018;27(6):1219–1233. <http://dx.doi.org/10.1007/s00586-017-5301-6>
61. Hauswald M, Braude D. Spinal immobilization in trauma patients: is it really necessary? *Curr Opin Crit Care*. 2002;8(6):566–570. <http://dx.doi.org/10.1097/00075198-200212000-00014>
62. Hankins DG, Rivera-Rivera EJ, Ornato JP, Robert A, Blackwell T, Domeier RM. Spinal immobilization in the field: clinical clearance criteria and implementation. *Prehosp Emerg Care*. 2001;5(1):88–93. DOI: [10.1080/10903120190940416](http://dx.doi.org/10.1080/10903120190940416)
63. Cacho García S, Peña Otero D, Eguillor Mutiloa M. Efficacy of cervical immobilization in multiple trauma patients. *Int J Crit Care Emerg Med*. 2019;5(1): Art. #061.
[doi.org/10.23937/2474-3674/1510061](http://dx.doi.org/10.23937/2474-3674/1510061)
64. Stiell IG, Bennett C. Implementation of clinical decision rules in the emergency department. *Acad Emerg Med*. 2007;14(11):955–959.
<http://dx.doi.org/10.1197/j.aem.2007.06.039>

65. Ahn H, Singh J, Nathens A, MacDonald RD, Travers A, Tallon J, Fehlings MG, Yee A. Pre-hospital care management of a potential spinal cord injured patient: A systematic review of the literature and evidence-based guidelines. *J Neurotrauma*. 2011;28(8):1341–1361. <http://dx.doi.org/10.1089/neu.2009.1168>
66. Desai S, Liu C, Kirkland SW, Krebs LD, Keto-Lambert D, Rowe BH. Effectiveness of implementing evidence-based interventions to reduce C-spine image ordering in the emergency department: a systematic review. *Acad Emerg Med*. 2018;25(6):672–683. <http://dx.doi.org/10.1111/acem.13364>
67. McDonald NE, Curran-Sills G, Thomas RE. Outcomes and characteristics of non-immobilised, spine-injured trauma patients: a systematic review of prehospital selective immobilisation protocols. *Emerg Med J*. 2016;33(10):732–740. <http://dx.doi.org/10.1136/emmermed-2015-204693>
68. Quinn RH, Williams J, Bennett BL, Stiller G, Islas AA, Mccord S. Wilderness Medical Society practice guidelines for spine immobilization in the austere environment: 2014 update. *Wilderness Environ Med*. 2014;25(4 Suppl):S105–S117. <http://dx.doi.org/10.1016/j.wem.2014.05.004>
69. Cone DC, Wydro GC, Mininger CM. Current practice in clinical cervical spinal clearance: implication for EMS. *Prehosp Emerg Care*. 1999;3(1):42–46. <http://dx.doi.org/10.1080/10903129908958905>
70. Acheson N. What is the difference between an algorithm and a protocol, and why does it matter? 2016. [Cited 27 February 2021]. Available from: <https://www.linkedin.com/pulse/what-difference-between-algorithm-protocol-why-does-matter-acheson/>
71. Meldon SW, Brant TA, Cydulka RK, Collins TE, Shade BR. Out-of-hospital cervical spine clearance: agreement between emergency medical technicians and emergency physicians. *J Trauma*. 1998;45(6):1058–1061. <http://dx.doi.org/10.1097/00005373-199812000-00014>
72. Stiell IG, Clement CM, O'Connor A, Davies B, Leclair C, Sheehan P, Clavet T, Beland C, MacKenzie T, Wells GA. Multicentre prospective validation of use of the Canadian C-Spine Rule by triage nurses in the emergency department. *Can Med Assoc J*. 2010;182(11):1173–1179. <http://dx.doi.org/10.1503/cmaj.091430>

73. Stiell IG, Clement CM, McKnight RD, Brison R, Schull MJ, Rowe BH, Worthington JR, Eisenhauer MA, Cass D, Greenberg G, et al. The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. *N Engl J Med*. 2003;349(26):2510–2518. <http://dx.doi.org/10.1056/NEJMoa031375>
74. Ten Brinke JG, Gebbink WK, Pallada L, Saltzherr TP, Hogervorst M, Goslings JC. Value of prehospital assessment of spine fracture by paramedics. *Eur J Trauma Emerg Surg*. 2018;44(4):551–554. <http://dx.doi.org/10.1007/s00068-017-0828-0>
75. Matteucci MJ, Moszyk D, Migliore SA. Agreement between resident and faculty emergency physician in the application of NEXUS criteria for suspected cervical spine injuries. *J Emerg Med*. 2015;48(4):445–449. <http://dx.doi.org/10.1016/j.jemermed.2014.11.006>
76. Ullrich A, Hendey GW, Geiderman J, Shaw SG, Hoffman J, Mower WR. Distracting painful injuries associated with cervical spinal injuries in blunt trauma. *Acad Emerg Med*. 2001;8(1):25–29. DOI: [10.1111/j.1553-2712.2001.tb00542.x](https://doi.org/10.1111/j.1553-2712.2001.tb00542.x)
77. Evans D, Vera L, Jeanmonod D, Pester J, Jeanmonod R. Application of National Emergency X-Ray Utilizations Study low-risk c-spine criteria in high-risk geriatric falls. *Am J Emerg Med*. 2015;33(9):1184–1187. <http://dx.doi.org/10.1016/j.ajem.2015.05.031>
78. Craxford S, Bayley E, Walsh M, Clamp J, Boszczyk BM, Stokes OM. Missed cervical spine injuries. A national survey of the practice of evaluation of the cervical spine in confused and comatose patients. *Bone Joint J*. 2016;98-B(6):825–828. <http://dx.doi.org/10.1302/0301-620X.98B6.37435>
79. Hoffman J, Wolfson A, Todd K, Mower W. Selective cervical spine radiography in blunt trauma: methodology of the National Emergency X-Radiography Utilization Study (NEXUS). *Ann Emerg Med*. 1998;32(4):461–469. [http://dx.doi.org/10.1016/S0196-0644\(98\)70176-3](http://dx.doi.org/10.1016/S0196-0644(98)70176-3)
80. Dickinson G, Stiell IG, Schull M, Brison R, Clement CM, Vandemheen KL, Cass D, McKnight D, Greenberg G, Worthington JR, et al. Retrospective application of the NEXUS low-risk criteria for cervical spine radiography in Canadian emergency departments. *Ann Emerg Med*. 2004;43(4):507–514. <http://dx.doi.org/10.1016/j.annemergmed.2003.10.036>
81. Ngatchou W, Beirnaert J, Lemogoum D, Bouland C, Youatou P, Ramadan AS, Sontou R, Alima MB, Plumaker A, Guimfacq V, et al. Application of the Canadian C-spine rule and

- NEXUS low criteria and results of cervical spine radiography in emergency condition. *Pan Afr Med J.* 2018;30: Art. #157. <http://dx.doi.org/10.11604/pamj.2018.30.157.13256>
82. Kerr D, Bradshaw L, Kelly A. Implementation of the Canadian C-Spine Rule reduces cervical spine X-ray rate for alert patients with potential neck injury. *J Emerg Med.* 2005;28(2):127–131. <http://dx.doi.org/10.1016/j.jemermed.2004.08.016>
83. Kauppila T, Virta J, Lindgren L, Virkkunen I, Kämäräinen A. Alcohol use in the prehospital setting: a diagnostic challenge in patients treated by a physician staffed mobile intensive care unit. *SpringerPlus.* 2016;5(1): Art. #1247. <http://dx.doi.org/10.1186/s40064-016-2921-y>
84. Domeier RM, Evans RW, Swor RA, Rivera-Rivera EJ, Frederiksen MS. Prospective validation of out-of-hospital spinal clearance criteria: a preliminary report. *Acad Emerg Med.* 1997;4(6):643–646. <http://dx.doi.org/10.1111/j.1553-2712.1997.tb03588.x>
85. Scheetz LJ. Comparison of type and severity of major injuries among undertriaged and correctly triaged older patients. *J Emerg Med.* 2012;43(6):1020–1028. <http://dx.doi.org/10.1016/j.jemermed.2011.09.036>
86. Barry TB, McNamara RM. Clinical decision rules and cervical spine injury in an elderly patient: a word of caution. *J Emerg Med.* 2005;29(4):433–436. <http://dx.doi.org/10.1016/j.jemermed.2005.05.006>
87. Gottschalk SB, Wood D, De Vries S, Wallis LA, Bruijns S. The Cape Triage Score: a new triage system South Africa. Proposal from the Cape Triage Group. *Emerg Med J.* 2006;23(2):149–153. <http://dx.doi.org/10.1136/emj.2005.028332>
88. Mould-Millman N, Colborn K, De Vries S, Dixon J, Hodkinson P, Ginde A, Wallis L. Out-of-hospital application of the South African Triage Scale (SATS): discordance between gold standard and medic triage. *Ann Emerg Med.* 2016;68(4 Suppl):S64. <http://dx.doi.org/10.1016/j.annemergmed.2016.08.176>
89. Tatum JM, Dhillon NK, Ko A, Smith EJT, Melo N, Barmparas G, Ley EJ. Refusal of cervical spine immobilization after blunt trauma: implications for initial evaluation and management: a retrospective cohort study. *Int J Surg.* 2017;48:228–231. <http://dx.doi.org/10.1016/j.ijsu.2017.11.027>

Figures

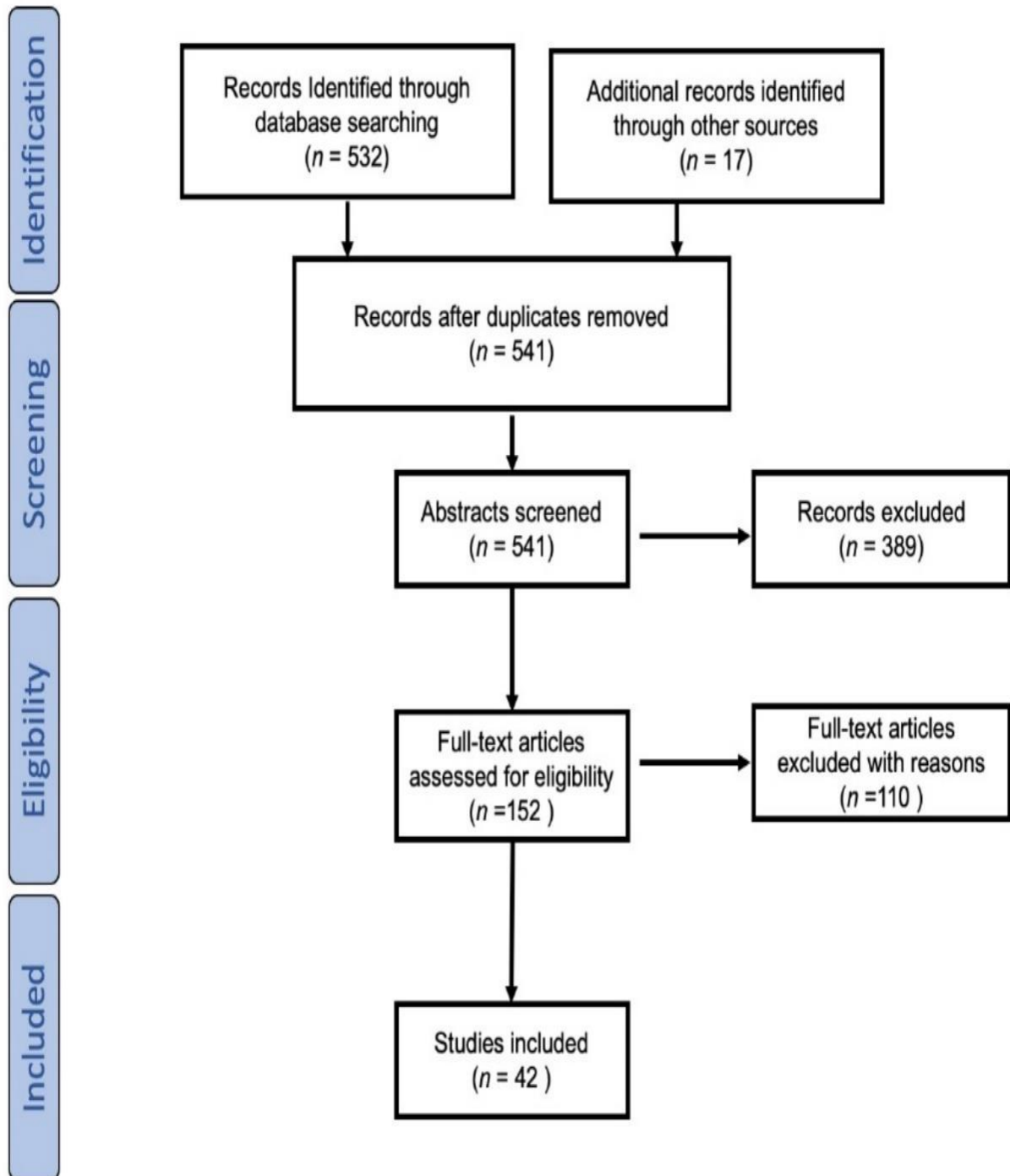


Figure 1: Prisma diagram describing selection of articles for review.

Table 1: PRISMA-ScR Checklist

Section	Item	PRISMA-ScR checklist item	Reported on page #
Title			
Title	1	Identify the report as a scoping review.	
Abstract			
Structured summary	2	Provide a structured summary including, as applicable: background, objectives, eligibility criteria, sources of evidence, charting methods, results and conclusions that relate to the review question(s) and objective(s).	
Introduction			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review question(s)/objective(s) lend themselves to a scoping review approach.	
Objectives	4	Provide an explicit statement of the question(s) and objective(s) being addressed with reference to their key elements (e.g., population or participants, concepts and context), or other relevant key elements used to conceptualize the review question(s) and/or objective(s).	
Methods			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify the characteristics of the sources of evidence (e.g., years considered, language, publication status) used as criteria for eligibility, and provide a rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with authors to identify additional sources) in the search, as well as the date the most recent search was executed.	
Search	8	Present the full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Selection of sources of	9	State the process for selecting sources of evidence (i.e., screening, eligibility) included	
evidence		in the scoping review.	
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., piloted forms; forms that have been tested by the team before their use, whether data charting was done independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	
Critical appraisal of individual sources of evidence	12	<i>If done</i> , provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	
Summary measures	13	<i>Not applicable for scoping reviews.</i>	
Synthesis of results	14	Describe the methods of handling and summarizing the data that were charted.	
Risk of bias across studies	15	<i>Not applicable for scoping reviews.</i>	
Additional analyses	16	<i>Not applicable for scoping reviews.</i>	
Results			
Selection of sources of evidence	17	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	
Characteristics of sources of evidence	18	For each source of evidence, present characteristics for which data were charted and provide the citations.	
Critical appraisal within sources of evidence	19	<i>If done</i> , present data on critical appraisal of included sources of evidence (see item 12).	
Results of individual sources of evidence	20	For each included source of evidence, present the relevant data that were charted that relate to the review question(s) and objective(s).	
Synthesis of	21	Summarize and/or present the charting results as they relate to the review	

Section	Item	PRISMA-ScR checklist item	Reported on page #
results		question(s) and objective(s).	
Risk of bias across studies	22	<i>Not applicable for scoping reviews.</i>	
Additional analyses	23	<i>Not applicable for scoping reviews.</i>	
Discussion			
Summary of evidence	24	Summarize the main results (including an overview of concepts, themes, and types of evidence available), explain how they relate to the review question(s) and objectives, and consider the relevance to key groups.	
Limitations	25	Discuss the limitations of the scoping review process.	
Conclusions	26	Provide a general interpretation of the results with respect to the review question(s) and objective(s), as well as potential implications and/or next steps.	
Funding			
Funding	27	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	

SUPPLEMENTARY FILE

Table 2. List of articles identified and included in the scoping review (n=42).

#	Author, year	Journal	Title	Study design	Study aim	Setting	Theme
1	Armstrong et al., 2007	Emergency Medical Journal	Prehospital clearance of the cervical spine: does it need to be a pain in the neck?	Observational, clinical audit	To determine whether the incidence of unnecessary c-spine immobilization by ambulance personnel could be safely reduced through the implementation of an evidence-based algorithm	Prehospital United Kingdom	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient centered selective SMR algorithm which goal is to minimize harms associated to SMR devices

2	Burton et al., 2006	Journal of Trauma	A statewide, prehospital emergency medical service selective patient spine immobilization protocol.	Observational, retrospective chart review	To evaluate the practices and outcomes associated with a statewide, EMS protocol for trauma patient spine assessment and selective patient immobilization	Prehospital United States of America, rural	<i>Barrier:</i> <ul style="list-style-type: none"> • Lack of guideline compliance • Protocol miss/protocol deficiency <i>Adverse event:</i> <ul style="list-style-type: none"> • Under-immobilization
3	Burton et al., 2005	Prehospital Emergency Care	EMS provider findings and interventions with a statewide EMS spine assessment protocol.	Observational, prospective descriptive study	To describe the utilization and findings with a statewide, prehospital spine-assessment protocol for EMS providers in a rural state	Prehospital United States of America, rural	-

4	Domeier et al., 2002	Journal of Trauma	Multicenter prospective validation of prehospital clinical spinal clearance criteria	Observational, prospective descriptive study	To evaluate five prehospital clinical criteria—altered mental status, neurologic deficit, spine pain or tenderness, evidence of intoxication, or suspected extremity fracture—the absence of which identify prehospital trauma patients without a significant spine injury	Prehospital United States of America	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Lack of guideline compliance • Protocol miss/protocol deficiency <p><i>Adverse event:</i></p> <ul style="list-style-type: none"> • Missed injury
5	Connor et al., 2013	Emergency Medical Journal	Prehospital immobilization: an initial consensus statement	Consensus statement	To review the evidence available on the practice of spinal immobilization in the prehospital environment	Prehospital	-

#	Author, year	Journal	Title	Study design	Study aim	Setting	Theme
6	Domeier et al., 2005	Annals of Emergency Medicine	Prospective performance assessment of an out-of-hospital protocol for selective spine immobilization using clinical spine clearance criteria.	Observational, prospective descriptive study	To determine whether the use of an EMS protocol for selective spine immobilization would result in appropriate immobilization without spinal cord injury associated with non-immobilization	Prehospital United States of America	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Lack of guideline compliance • Protocol misapplication/protocol violation <p><i>Adverse event:</i></p> <ul style="list-style-type: none"> • Missed injury
7	Stroh and Braude, 2001	Annals of Emergency Medicine	Can an out-of-hospital cervical spine clearance protocol identify all patients with injuries? An argument for	Observational, retrospective chart review	To evaluate the sensitivity of EMS selective spine immobilization protocol in identifying patients with potential cervical	Emergency Department and prehospital,	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Lack of guideline compliance

			selective immobilization.		injuries, and whether the protocol was safe in the prehospital setting	United states of America	<ul style="list-style-type: none"> • Protocol miss/ deficiency • Protocol misapplication/ violation <p><i>Adverse event:</i> Missed injury</p>
8	Ahn et al., 2011	Journal of Neurotrauma	Pre-hospital care management of a potential spinal cord injured patient. A systematic review of the literature and evidence-based guidelines.	Systematic review	To provide evidence-based guidelines to identify optimal care in key areas in the pre-hospital setting for patients with potential SCI	Not applicable	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Lack of guideline compliance

9	Oteir et al., 2014	Prehospital and Disaster Medicine	The prehospital management of suspected spinal cord injury: an update	Review	To review the available literature on the epidemiology of TSCI and practice of prehospital spinal immobilization	Not applicable	-
10	Stiell and Bennett, 2007	Academic Emergency Medicine	Implementation of clinical decision rules in the emergency department.	Review	To review the results of implementation studies evaluating the effect of four Clinical Decision Rules: the Ottawa Ankle Rules, the Ottawa Knee Rule, the Canadian C- Spine Rule, and the Canadian CT Head Rule	Not applicable	<i>Facilitator:</i> <ul style="list-style-type: none"> • Development and adoption of context fit decision tool criteria • Well established and comprehensive implementation approach based

							<p>on behavioral change theory</p> <p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Variation of guideline utilization • Protocol misapplication
11	Vaillancourt et al., 2009	Annals of Emergency Medicine	The out-of-hospital validation of the Canadian C-spine rule by paramedics.	Prospective multicenter cohort study	To prospectively assess the performance characteristics, reliability, and clinical sensibility of the CCSR for alert, stable, and cooperative trauma patients when used by paramedics in the prehospital setting.	Prehospital Canada	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Protocol misapplication

#	Author, year	Journal	Title	Study design	Study aim	Setting	Theme
12	Gonzalez et al., 2013	American Surgeon	Prehospital clinical clearance of the cervical spine: a prospective study.	Prospective Study	To prospectively assess whether EMS personnel can effectively clinically clear the c-spine of blunt trauma injured patients with a GCS of 14 and above.	Prehospital United States of America, Urban	<i>Barrier:</i> <ul style="list-style-type: none"> Lack of guideline compliance
13	Clement et al., 2011	International Emergency Nursing	Perceived facilitators and barriers to clinical clearance of the cervical spine by emergency department nurses: a major step towards changing	Prospective quantitative survey	To identify potential facilitators and barriers to an implementation policy that would allow nurses to clinically clear the c-spine of minor trauma patients	Emergency Departments Canada	<i>Facilitator:</i> <ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioral change theory

			practice in the emergency department.				<i>Barrier:</i> <ul style="list-style-type: none"> Lack of guideline compliance
14	Jin et al., 2007	European Journal of Trauma and Emergency Surgery	A retrospective study of five clinical criteria and one age criterion for selective prehospital spinal immobilization	Retrospective chart review	To retrospectively investigate and examine the sensitivity of a selective prehospital immobilization protocol that adds an age criterion to five clinical spine clearance criteria.	Emergency Department and prehospital, Netherlands	<i>Facilitator:</i> <ul style="list-style-type: none"> Criterion modification
15	Kreinst et al., 2017	European Journal of Trauma and Emergency Surgery	Expertise of German paramedics concerning the prehospital treatment of patients with spinal trauma.	Questionnaire	To analyze German paramedics' subjective uncertainty in terms of their prehospital assessment and treatment	Prehospital, Germany	<i>Facilitator:</i> <ul style="list-style-type: none"> Patient centered selective SMR algorithm

					of patients suffering from spine injuries		which goal is to minimize harms associated to SMR devices
16	Larson et al., 2018	Journey of Emergency Nursing	The use of clinical cervical spine clearance in trauma patients: a literature review.	Systematic literature review	To review the available literature to present evidence of the risks associated with the use of cervical collars, and to identify the latest evidence recommendation regarding clinical clearance of C-Spine immobilization precautions in trauma patients.	Not applicable	<i>Barrier:</i> <ul style="list-style-type: none"> Lack of guideline compliance <i>Adverse event:</i> <ul style="list-style-type: none"> Over-immobilization

17	Clement et al., 2016	International Emergency Nursing	Facilitators and barriers to application of the Canadian C-spine rule by emergency department triage nurses.	Survey	To evaluate the nurses, physicians and administrators views on the facilitators and barriers to the implementation of the CCSR	Emergency Department Canada	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Well established and comprehensive implementation approach based on behavioral change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Lack of guideline compliance • Protocol misapplication
#	Author, year	Journal	Title	Study design	Study aim	Setting	Theme

18	Fontaine et al., 2018	Journal of Emergency Nursing	Cervical spine collar removal by emergency room nurses: a quality improvement project.	Practice improvement project	This practice improvement project had three aims: 1. To train ED nurses how to use CCSR in alert, orientated, low risk, adult trauma patient, in so doing remove the cervical collar; 2. to monitor its use throughout the project, and 3. to compare the assessment of nurses using the CCSR with the assessments done by emergency physicians on the same patients.	Emergency Department, Canada	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Well established and comprehensive implementation approach based on behavioral change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Protocol misapplication • Lack of guideline compliance
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19	Desai et al., 2018	Academic Emergency Medicine	Effectiveness of implementing evidence-based interventions to reduce C-spine image ordering in the emergency department: a systematic review.	Systematic review	To review the literature on the implementation and effectiveness of evidence-based interventions aimed at reducing C-spine imaging in adults presenting to the ED with neck trauma.	Not applicable	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioral change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> Lack of guideline compliance
20	Myers et al., 2009	International Journal of Emergency Medicine	Efficacy and compliance of a prehospital spinal immobilization guideline.	Retrospective chart review	To retrospectively examine the efficacy of a prehospital spinal clearance guideline and	Emergency Department and prehospital,	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> Criteria medication <p><i>Barrier:</i></p>

					triage/management of these injuries.	United states of America.	<ul style="list-style-type: none"> Lack of guideline compliance <p><i>Adverse event:</i></p> <ul style="list-style-type: none"> Missed injury
21	Cardozo and Angus, 2015	Journal of Trauma Nursing	Use of an electronic C-spine clearance strategy to ensure compliance with confrontational examinations.	Retrospective chart review	To retrospectively evaluate and improve the documentation of c-spine clearances by standardizing the confrontational spine examination for patients sustaining blunt trauma using the EMR.	Emergency Department, United States of America	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioral change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> Lack of guideline compliance

#	Author, year	Journal	Title	Study design	Study aim	Setting	Theme
22	Kornhall et al., 2017	Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine	The Norwegian guidelines for the prehospital management of adult trauma patients with potential spinal injury.	Systematic review	To review the evidence base in order to provide/develop practice guideline recommendations for the management of adult trauma patients with potential spinal injury in the prehospital setting.	Not applicable	<i>Facilitator:</i> Patient centered selective SMR algorithm which goal is to minimize harms associated to SMR devices
23	Kreinst et al., 2016	Scandinavian Journal of Trauma, Resuscitation and	Development of a new emergency medicine spinal immobilization protocol for trauma patients and a test of applicability by	Survey after systematic review	To review the evidence in order to develop a protocol that supports decision-making for SMR in adult trauma patients and to carry out the first	Prehospital, Europe	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient centered selective SMR algorithm which goal is to minimize harms

		Emergency Medicine	German emergency care providers.		applicability test by emergency medical personnel		associated to SMR devices
24	McDonald et al., 2016	Emergency Medical Journal	Outcomes and characteristics of non- immobilized, spine- injured trauma patients: a systematic review of prehospital selective immobilization protocols.	Systematic review	To review the literature in order to assess prehospital selective immobilization protocols across a range of outcomes, including neurological deterioration and characteristics of injured, non-immobilized patients.	Not applicable	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Patient centered selective SMR algorithm which goal is to minimize harms associated to SMR devices <p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Protocol miss/ deficiency <p><i>Adverse event:</i></p> <ul style="list-style-type: none"> • Missed injury

25	Moser et al., 2018	Europe Spine Journal	Validity and reliability of clinical prediction rules used to screen for cervical spine injury in alert low-risk patients with blunt trauma to the neck: part 2. A systematic review from the Cervical Assessment and Diagnosis Research Evaluation (CADRE) Collaboration.	Systematic review	To review the literature and update findings of the 2000–2010 Bone and Joint Decade Task Force on Neck Pain and its Associated Disorders (Neck Pain Task Force) on the validity and reliability of clinical prediction rules used to screen for cervical spine injury in alert low-risk adult patients with blunt trauma to the neck.	Not applicable	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioral change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> Protocol misapplication Lack of guideline compliance
26	Castro-Marin, 2020	Prehospital Emergency Care	Prehospital protocols reducing long spinal board use are not associated with a	Retrospective, observational study	To determine if implementation of SMR protocols, which reduce	Emergency Department, and Prehospital,	-

			change in incidence of spinal cord injury.		LSB use, was associated with an increase in SCI	United States of America	
#	Author, year	Journal	Title	Study design	Study aim	Setting	Theme
27	Hauswald and Braude, 2002	Current Opinion in Critical Care	Spinal immobilization in trauma patients: is it really necessary?	Opinion statement	To review the evidence on minimizing harm from both under- and over-immobilization in trauma patients.	Not applicable	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient centered selective SMR algorithm which goal is to minimize harms associated to SMR devices
28	Dunn et al., 2004	Prehospital Emergency Care	Are emergency medical technician-basics able to use a selective immobilization of the	Preliminary report: a prospective	To determine whether EMT-Basics can use a protocol that allows for	Prehospital, United States of America	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient centered selective SMR algorithm which

			cervical spine protocol? A preliminary report.	scenario- based study	selective immobilization of the cervical spine.		<p>goal is to minimize harms associated to SMR devices</p> <ul style="list-style-type: none"> • Well established and comprehensive implementation approach based on behavioral change theory • Development and adoption of context fit decision tool criteria <p><i>Barrier:</i></p>
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							<ul style="list-style-type: none"> • Protocol misapplication • Protocol deficiency • Lack of guideline compliance <p><i>Adverse:</i></p> <ul style="list-style-type: none"> • Increase in false positive cases
29	Collins et al., 2013	European Journal of Emergency Medicine	The NEXUS criteria: do they stand the test of time?	Case study	To conduct a case study report on the elderly population who are more likely to sustain c-spine injury because of blunt trauma as oppose to the younger patients, urging caution in using NEXUS	Emergency Department, Ireland.	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Protocol miss <p><i>Adverse event:</i></p> <ul style="list-style-type: none"> • Missed injury

					criteria alone in determining the need for radiography of cervical spine in the elderly		
30	Hankins et al., 2001	Prehospital Emergency Care	Spinal immobilization in the field: clinical clearance criteria and implementation.	Consensus statement report/presentation	To review the evidence to highlight and discuss controversies around SMR.	Not applicable	-
31	Hong et al., 2014	Western Journal of Emergency Medicine	Comparison of three prehospital cervical spine protocols for missed injuries.	Cross-sectional study	To compare three existing EMS SMR protocols; the PHTLS; the Domeier protocol; and the Hankins' criteria, by determining the proportion of patients who would require cervical SMR per	Prehospital United States of America, Urban	<i>Barrier:</i> <ul style="list-style-type: none"> • Lack of guideline compliance

					protocol and evaluate the number of missed cervical spine injuries, had each protocol been followed with 100% compliance.		
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#	Author, year	Journal	Title	Study design	Study aim	Setting	Theme
32	Maschmann et al., 2019	Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine	New clinical guidelines on the spinal stabilisation of adult trauma patients – consensus and evidence based	Systematic Review-Consensus Report	To review the literature to provide updated clinical guidelines on prehospital procedures for spinal stabilisation of adult trauma patients in Denmark.	Not applicable	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Patient centred selective SMR algorithm which goal is to minimise harms associated to SMR devices <p><i>Adverse event:</i></p> <ul style="list-style-type: none"> • Over-immobilisation / over triage
33	Oteir et al., 2017	Prehospital Emergency Care	Prehospital predictors of traumatic spinal cord injury in Victoria, Australia.	Retrospective cohort study – chart review	To retrospectively identify the predictors of TSCI and describe the differences between confirmed and potential TSCI cases in the prehospital setting	Emergency Department, and Prehospital, Australia	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Development and adoption of context fit decision tool criteria

							<p><i>Adverse event:</i></p> <ul style="list-style-type: none"> • SMR practice increasing on scene time
34	Cacho García et al., 2019	International Journal of Critical Care and Emergency Medicine	Efficacy of cervical immobilisation in multiple trauma patients.	Bibliographic narrative review	To review the literature and contrast the effectiveness of immobilisation in multiple trauma patients.	Not applicable	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Development and adoption of context fit decision tool criteria
35	Sebastian et al., 2001	California Journal of Emergency Medicine	EMS Adherence to a pre-hospital cervical spine clearance protocol	Retrospective descriptive study	To retrospectively determine the degree of adherence to a c-spine clearance protocol by pre-hospital EMS personnel by both self-assessment and receiving hospital assessment, to describe deviations from the protocol, and to determine if the rate of	Emergency Department, and Prehospital, United States of America.	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Well established and comprehensive implementation approach based on

					compliance by paramedic self-assessment differed from receiving hospital assessment		behavioural change theory <i>Barrier:</i> <ul style="list-style-type: none"> Lack of guideline compliance
36	Paterek et al., 2015	Spine	Characteristics of trauma patients with potential cervical spine injuries under immobilised by prehospital providers.	Retrospective chart review	To retrospectively determine the characteristics of patients under immobilized by prehospital providers.	Emergency Department, and Prehospital, United States of America.	<i>Barrier:</i> <ul style="list-style-type: none"> Lack of guideline compliance <i>Adverse event:</i> <ul style="list-style-type: none"> Under-immobilization
#	Author, year	Journal	Title	Study design	Study aim	Setting	Theme

37	Tatum et al., 2017	Journal of Surgical Research	Validation of a field spinal motion restriction protocol in a level I trauma centre.	Retrospective Chart Review	To retrospectively determine the sensitivity and specificity of a new field spinal clearance protocol to be used by prehospital EMS.	Emergency Department, and Prehospital, United States of America.	-
38	Underbrink et al., 2018	Prehospital Emergency Care Journal	New immobilisation guidelines change EMS critical thinking in older adults with spine trauma.	Retrospective observational study	To retrospectively examine older adult (>60years) trauma patients with a cervical spine fracture or cervical cord injury and compare the type of spinal precautions used by EMS and identify changes in hospital outcomes before and after protocol implementation	Emergency Department, and Prehospital, United States of America.	<i>Facilitator:</i> <ul style="list-style-type: none"> Development and adoption of context fit decision tool criteria
39	Pitt et al., 2006	Emergency Medical Journal	Removal of C-spine protection by A&E triage	Prospective trial	To investigate and determine whether triage nurses could safely apply a set of clinical criteria,	Emergency Department, Scotland	-

			nurses: a prospective trial of a clinical decision-making instrument.		removing hard collars and spinal boards at initial triage assessment.		
40	Fischer et al., 2018	Prehospital Emergency Care	Spinal motion restriction in the trauma patient – a joint position statement.	Joint position statement	To review the evidence and provide an updated guidance on the practices of SMR in the trauma patient by EMS personnel, EMS medical directors, emergency physicians, trauma surgeons, and nurse.	Not applicable	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient centred selective SMR algorithm which goal is to minimise harms associated to SMR devices
41	Coggins et al., 2019	Australasian Emergency Care	A prospective evaluation of cervical spine immobilisation in low-risk trauma patients at a	Prospective multi-methods evaluation	To prospectively investigate the practices and rate of concordance with established international guidelines.	Emergency Department, Australia.	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient centred selective SMR algorithm which goal is to minimise

			tertiary emergency department.				harms associated to SMR devices <i>Barrier:</i> • Lack of guideline compliance
42	Stanton et al., 2017	African Journal of Emergency Medicine	Cervical collars and immobilisation: a South African best practice recommendation	Review	To review the evidence set out to update the practice of SMR and present South African Guidelines which are in line with current research and clinical understanding	Not applicable	

Key to abbreviations: *ALS* – Advanced Life Support; *BLS* – Basic Life Support; *EMT* – Emergency Medical Technician; *EMS* – Emergency Medical Service; *CCC* – Clinical cervical-spine clearance; *SMR* – Spinal motion restriction, also known as spinal immobilisation; *ED* – Emergency Department; *EC* – Emergency Centre; *EMR* – Electronic Medical Records; *LSB* – Long Spine Board; *SCI* – Spinal Cord Injury; *TSCI* – Traumatic Spinal Cord Injury; *C-spine* – Cervical Spine

Part C: Appendices

Appendix A: Prehospital Emergency Care Journal: Instructions for Authors

The journal selected for publication is the Prehospital Emergency Care (Prehosp. Emerg. Care) Journal, as the findings from our scoping review have relevance to an international audience, and open access is available.

The instructions for Authors can be found at the following link:

<https://www.tandfonline.com/action/authorSubmission?show=instructions&journalCode=ipec20#prep>

Appendix B: Research Protocol

FACTORS WHICH AFFECT THE APPLICATION AND IMPLEMENTATION OF A SPINAL MOTION RESTRICTION PROTOCOL BY PREHOSPITAL PROVIDERS IN LOW RESOURCE SETTINGS: A SCOPING REVIEW

STUDENT: Student name: Charlene Geduld

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Affiliation: University of Cape Town

Student number: GDLCHA002

SUPERVISOR(s): Name of supervisor: Colleen Saunders

Degree(s):BSc (MED) Hons, PhD

Affiliation: University of Cape Town

Name of co-supervisor: Henra Muller

Degree(s):M Tech Radiography (Diagnostic)

Affiliation: Central University of Technology

This study is in partial fulfilment of the MPhil Emergency Medicine Degree

DECLARATION

I, **Charlene Geduld**, hereby declare that the work contained in this assignment is my original work and that I have not previously submitted it, in its entirety or in part, at any university for a degree.

Signature:

Date: 1 July 2020

INTRODUCTION

Spinal cord injury, or nerve root injury, is a recognised complication of spinal trauma where it is referred to as Traumatic Spinal Cord Injury (TSCI). Over the last several decades, South African (SA) prehospital emergency medical services (EMS) staff have routinely immobilised patients with any trauma related injury as provision for any underlying TSCI. Spinal motion restriction (SMR) is primarily performed to minimise or prevent further damage to the spinal cord, which can result in further instability of the spinal column. Cervical spine immobilisation (CSI) is a subset of SMR with specific consideration to immobilising the cervical spine (C-spine), and this is intended to protect the potential C-spine injury and prevent injury progression (1). Current practice is to assume the presence of C-spine injury in any patient with a mechanism of injury suggestive of CSI where there are relevant clinical findings and proceed to triple immobilisation of the C-Spine. The triple immobilisation includes the use of a cervical collar, head restraints and either a long spinal board or orthopaedic scoop stretcher (2).

Historically, the decision making for the safe removal of immobilisation devices, such as those used for CSI in particular, was done by physicians within the hospital setting (3)(4)(5). One method used to clear the C-spine was is a clinical spinal clearance tool, the Canadian C-Spine Rule (CCSR), initially designed and validated for usage in the stable and alert trauma patient who presents to the emergency department (ED) and in whom a cervical spinal injury was a concern (4). Furthermore, the CCSR was not only used to determine the safe removal of immobilisation devices (neck collar) but also to identify the need for diagnostic imaging. This was done to reduce the use of C-spine imaging, thereby decreasing patient exposure to radiation, minimising health care expenditure for the patient and contributing to patient satisfaction (3)(4)(5).

Recent evidence has started to question and raise concern about the immobilisation practices of EMS providers. This includes SMR being unnecessarily performed (i.e. inappropriate patient selection and/or low risk of TSCI post-trauma) (6)(7)(8)(9)(10)(11), time consuming (i.e. delay in identification and treatment of life-threatening conditions) (6)(10), and inappropriately applied (i.e. poorly performed practice, and/or incorrect equipment used for procedure) (6)(11). In addition, evidence highlighted that SMR is not

without its harmful effects where it is viewed that the risks and complications far outweigh its benefits. In CSI, in particular, the harms associated with the use of neck collars have been linked to causing tissue necrosis, increased movement of unstable fractures, increased intracranial pressure, and general discomfort for the patient (6)(11). Moreover, prolonged immobilisation has been linked to the development of pressure ulcers and general patient discomfort and pain. As a result, there have been recommendations for extending selective SMR protocol usage to ED nurses and EMS providers within the prehospital setting.

“Clinical decision (or prediction) rules help to reduce the uncertainty of medical decision making by standardising the collection and interpretation of clinical data” (12). Of late, various clinical methods for reliably determining the absence of clinically important spinal injury in the prehospital setting or the ED have been explored to eliminate long, needless uncomfortable immobilisation for some patients (1)(12)(13)(14)(15)(16)(17). Whilst literature has shown promising results in this regard; it is to be noted that most of these studies were conducted within high resource settings. As a result, the findings of such research may not necessarily be generalisable to different practice environments internationally, especially that of low resource settings. Moreover, it is to be noted that although favourable results were shown, some of the same literature identified limitations and barriers to the application of spinal immobilisation protocols. For these reasons, it was found necessary to conduct a scoping review to identify factors which may either limit or facilitate the safe and effective practice of selective SMR and/or CSI by EMS providers within low resource contexts.

Overall, the scoping review is aimed at identifying any knowledge and, or practice gaps, as it is believed that once this is done, it may guide future research of selective CSI and the implementation thereof within low resource settings. There is no dispute that there are several benefits to selective immobilisation protocols in both out of hospital and in-hospital settings, especially those operating within low resourced settings. These benefits include decreased costs to the patient and the healthcare setting, minimising concerns over patient discomfort and associated complications arising from C-spine immobilisation, and decreased prehospital time. Therefore, identification of system- specific barriers and

facilitators are important components of successful knowledge translation for the realization of such benefits.

AIM AND OBJECTIVES:

The aim of this scoping review is to identify the published literature describing the use of selective SMR decision support tools for adult, blunt trauma patients, and to identify the factors which may facilitate or challenge the safe and effective application of these tools by EMS personnel in low resource settings. In particular, we seek to answer the following questions:

- Which selective SMR decision support tools have been implemented and evaluated in the prehospital setting and/or are currently in use by EMS?
- What are the potential barriers and facilitators that EMS practitioners may encounter in applying selective SMR decision support tools?
- What are the potential adverse events associated with the application of selective SMR decision support tools by EMS personnel?

METHODOLOGY

Study design

The proposed study is a scoping review to identify the published literature describing the use of selective SMR decision support tools for adult, blunt trauma patients. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Review checklist will be used to structure the final report.

Search strategy and information sources

The Medline (via PubMed), Embase Cochrane, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Web of Science, Turning Research Into Practice (TRIP) and EBSCO host online databases will be searched using the following advanced search string in the first instance:

((emergency responders) OR (emergency care practitioner) OR (emergency medical technicians) OR (emergency medical services) OR (EMS) OR

(prehospital) OR (out-of-hospital) OR ("out of hospital") OR (ambulances) OR (paramedic)) AND (((cervical) OR (c-spine) OR (spinal injury)) NOT (cancer)) AND ((clearance) OR (protocol) OR (algorithm) OR (rule) OR (triage) OR (NEXUS) OR (Canadian C-spine)))) AND (trauma) AND (2000:2020[pdat])

Search results will be limited to those published in or after 2000. Reference lists of selected articles will also be examined for further articles, potentially meeting the search criteria.

Screening and eligibility

Article titles and abstracts will be screened for potential relevance and duplicate articles will be removed. Following this initial screening, the full text of articles identified in the first screening step will be reviewed and screened against the inclusion and exclusion criteria.

Articles for which the full text is not available in English will be excluded.

Studies will be eligible for inclusion if they describe the use of any clinical spinal clearance decision tools in the first line management of blunt trauma patients by medical practitioners in the ED or by EMS personnel working in a prehospital setting in any country. Studies that focus only on paediatric patients will be excluded as these patients are unable to describe their symptoms, and have unique anatomical, physiological and development characteristics. Studies describing patients who sustained penetrating injuries will be excluded since SMR may have minimal benefits to these patients as it is unlikely to cause instability (18), may be associated with higher mortality (19) (20), and may increase the risk of deterioration (21).

Data extraction

Information from studies meeting the eligibility criteria and passing the screening process will be extracted and charted for analysis. The following fields will be extracted for each article:

Author(s)

Year of publication

Bibliographic details

Study design

Study aim or purpose

Study setting and population

Findings or recommendations

Record of rationale for inclusion of the study

Results will then be classified under main conceptual themes and summarised.

ETHICAL CONSIDERATIONS

This study does not involve human participants. There is no risk to human participants in this study. All included documents are already published in the public domain and there are, therefore no concerns regarding confidentiality. Ethical approval of this study is, therefore not required; however, the study proposal will be submitted to the University of Cape Town Human Research Ethics Committee for confirmation and notification.

DISSEMINATION PLAN

It is anticipated that this scoping review will be submitted for publication in a DHET accredited, peer-reviewed journal. The findings of this study will also be written up and submitted in completion of the MPhil dissertation.

TIMELINE

It is anticipated that the search and review process will be completed by end 2020, and that the MPhil dissertation will be submitted for examination in early 2021.

REFERENCES

1. Larson S, Rn MSN, Cen C, Tcrn C, Delnat AU, Rn MSN, et al. The Use of Clinical Cervical Spine Clearance in Trauma Patients: A Literature Review. *J Emerg Nurs* [Internet]. 2018;44(4):368–74. Available from: <http://dx.doi.org/10.1016/j.jen.2017.10.013>
2. Care P. Prehospital clearance of the cervical spine: does it need to be a pain in the neck? 2007;501–3.
3. Stiell IG, Clement CM, Grimshaw J, Brison RJ, Rowe BH, Schull MJ, et al. Implementation of the Canadian C-Spine Rule: prospective 12 centre cluster randomised trial. *Br Med J*. 2009;1–7.
4. Stiell IG, Wells GA, Vandemheen KL, Clement CM, Lesiuk H, Maio VJ De, et al. The Canadian C-Spine Rule for Radiography in Alert and Stable Trauma Patients. 2001;286(15).
5. Stiell I, Clement C, Rowe B, Al E. The Canadian C-Spine Rule versus the NEXUS Low-Risk Criteria in Patients with Trauma. 2003;
6. Theodore N, Hadley MN. Prehospital Cervical Spinal Immobilization After Trauma. 2013;72(3):22–34.
7. Stanton D, Hardcastle T, Muhlbauer D, Zyl D Van. African Journal of Emergency Medicine Cervical collars and immobilisation: A South African best practice recommendation Minerves et immobilisations: Recommandation tirée des meilleures pratiques sud-africaines. *African J Emerg Med* [Internet]. 2017;7(1):4–8. Available from: <http://dx.doi.org/10.1016/j.afjem.2017.01.007>
8. Connor D, Greaves I, Porter K, Bloch M. Pre-hospital spinal immobilisation: an initial consensus statement. 2013;30(12):28–31.
9. Looby S, Flanders A. Spine Trauma. *Radiol Clin NA* [Internet]. 2011;49(1):129–63. Available from: <http://dx.doi.org/10.1016/j.rcl.2010.07.019>
10. Stuke LE, Pons PT, Guy JS, Chapleau WP, Butler FK, Mcswain NE. Prehospital

Spine Immobilization for Penetrating Trauma — Review and Recommendations From the Prehospital Trauma Life Support. 2011;71(3):763–70.

11. Sundstrøm T. Prehospital Use of Cervical Collars in Trauma Patients : 2014;540:531–40.
12. Vaillancourt C, Charette M, Kasaboski A, Maloney J, Wells GA, Stiell IG. Evaluation of the safety of C-spine clearance by paramedics : design and methodology. *BMC Emerg Med* [Internet]. 2011;11(1):1. Available from: <http://www.biomedcentral.com/1471-227X/11/1>
13. Kornhall DK, Jørgensen JJ, Brommeland T, Hyldmo PK, Asbjørnsen H. The Norwegian guidelines for the prehospital management of adult trauma patients with potential spinal injury. *Scand J Trauma Resusc Emerg Med* [Internet]. 2017;1–11. Available from: <http://dx.doi.org/10.1186/s13049-016-0345-x>
14. Fung P, Jin K, Goslings JC, Luitse J, Ponsen KJ. A Retrospective Study of Five Clinical Criteria and One Age Criterion for Selective Prehospital Spinal Immobilization. 2007;(4):401–7.
15. Kreinest M, Goller S, Grützner BGPA, Häske MKD. Expertise of German paramedics concerning the prehospital treatment of patients with spinal trauma. 2017;371–6.
16. Paykin G, Reilly GO, Ackland HM, Mitra B. The NEXUS criteria are insufficient to exclude cervical spine fractures in older blunt trauma patients. *Injury* [Internet]. 2020;48(5):1020–4. Available from: <http://dx.doi.org/10.1016/j.injury.2017.02.013>
17. Fontaine G, Student RN, Forgione M, Mba RN, Rn FL, Rn ML, et al. CERVICAL SPINE COLLAR REMOVAL BY EMERGENCY ROOM NURSES : A QUALITY. *J Emerg Nurs* [Internet]. 2018;44(3):228–35. Available from: <https://doi.org/10.1016/j.jen.2017.07.018>
18. Oteir AO, Ehs MS, Smith K, Grad H, Exec C, Grad BA, et al. The Prehospital Management of Suspected Spinal Cord Injury : An Update. 2020;(August 2014).

19. Haut ER, Kalish BT, Efron DT, Haider AH, Stevens KA, Kieninger AN, et al. Spine Immobilization in Penetrating Trauma : More harm than good? 2010;68(1):115–21.
20. Maschmann C, Jeppesen E, Rubin MA, Barfod C. New clinical guidelines on the spinal stabilisation of adult trauma patients – consensus and evidence based. 2019;1–10.
21. Vanderlan WB, Tew BE, Seguin CY, Mata MM, Yang JJ, Horst HM, et al. Neurologic Sequelae of Penetrating Cervical Trauma. 2009;34(24):2646–53.

Appendix C: HREC Approval Letter



UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee



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08 December 2020

HREC REF 859/2020

Dr Colleen Saunders
Department of Emergency Medicine
F51, OMB

Email: c.saunders@uct.ac.za
Student: GDLCHA002@myuct.ac.za

Dear Dr Saunders

PROJECT TITLE: FACTORS WHICH AFFECT THE APPLICATION AND IMPLEMENTATION OF A SPINAL MOTION RESTRICTION PROTOCOL BY PREHOSPITAL PROVIDERS IN LOW RESOURCE SETTINGS: A SCOPING REVIEW. (MPHIL CANDIDATE: NS C GEDULD)

Thank you for submitting your request to the Faculty of Health Sciences Human Research Ethics Committee.

The HREC note that the proposed study is a systematic review.

As the systematic review involves published literature available through publicly accessible electronic databases, research ethics review and approval is not required.

This is in accordance with Section 1.1.8 of the Department of Health's Ethics in Health Research: Principles, Processes and Structures (South African Department of Health, 2015), which states: *"Research that relies exclusively on publicly available information or accessible through legislation or regulation usually need not undergo formal ethics review. This does not mean that ethical considerations are irrelevant to the research."*

The HREC recommend that researchers refer to the PRISMA website, for the PRISMA statement and checklist, to facilitate the reporting of systematic reviews and meta-analyses. For more information, please refer to <http://www.prisma-statement.org>.

Further, fundamental ethical principles for health-related research should be considered in the objectives and methods of the systematic review. See, for example, the Declaration of Helsinki (Fortaleza, Brazil, 2013) and the Department of Health's Ethics in Health Research: Principles, Processes and Structures (South African Department of Health, 2015).

The HREC acknowledge that the PhD Candidate, NS Charlene Geduld, was also involved in this project.

Yours sincerely

Signature Removed

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE