



REVIEW ARTICLE

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



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ABSTRACT

Introduction: The safety and effectiveness of prehospital clinical c-spine clearance or spinal motion restriction (SMR) decision support tools are unclear. The present study aimed to examine the available literature on clinical cervical spine clearance and selective SMR decision support tools to identify possible barriers to implementation, safety, and effectiveness when used by emergency medical service (EMS) practitioners.

Method: We performed a focused scoping review of published literature on the prehospital use of clinical c-spine clearance and SMR decision tools in adult blunt trauma patients. The Medline, Embase, Cochrane Library, Cumulative Index of Nursing and Allied Health Literature, Web of Science, Turning Research into Practice and EBSCOhost online databases were searched (February 2021). The type of decision support tool and facilitators and barriers to its use were extracted from each included publication in accordance with a modified descriptive-analytical framework. Extracted data were subjected to thematic analysis.

Results: Following screening, forty-two articles were included in this scoping review. No studies conducted specifically in low resource settings were found. The majority of articles (57%) evaluated the use of specific SMR decision support tools, such as the National Emergency X-Radiography Utilization Study (NEXUS) and the Canadian C-spine Rule (CCR). Potential facilitators of safe and effective use were identified in 60%, and potential barriers to safe and effective use in 55% of included articles. Only one study evaluated the CCR when used by EMS practitioners, making it difficult to determine its appropriateness for implementation in the prehospital setting.

Conclusion: This is the first scoping review, to our knowledge, that has attempted to identify the possible barriers and facilitators to their implementation, safety, and effectiveness when used by EMS practitioners. Key issues identified included terminology, guideline compliance and implementation, and a lack of context-specific evidence. These may provide important considerations for future guideline development.

Introduction

Published estimates of the prevalence of cervical spine injury following blunt trauma are variable (2–7%) but consistently low [1–3]. Approximately 20% of trauma patients with a cervical spine injury suffer more specifically from a spinal cord injury [1], and are at risk of severe neurological consequences. However, there are differences in the reported incidence of traumatic spinal cord injury between high- and low-resource settings [4], most likely influenced by under-diagnosis and under-reporting in low-resource settings. Considering the potentially severe sequelae of spinal cord injuries, identifying these injuries is considered a priority in the initial prehospital management work up of the

trauma patient and can significantly influence patient outcome [5,6]. Early identification of potential spinal cord injuries can inform timely and appropriate transport and referral decisions [6]. Historically it was thought that differentiating between patients with and without spinal cord injuries could not be carried out by prehospital emergency medical service (EMS) practitioners [7], and this resulted in prehospital protocols incorporating a conservative, non-selective approach to spinal motion restriction (SMR) in trauma patients.

Traditional prehospital SMR practices, such as using cervical collars, head blocks, long spine boards, and spider harnesses, have come under scrutiny [8]. In some cases, SMR is considered to be unnecessarily performed due to inappropriate patient selection and the low risk of spinal

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cord injury post-trauma, leading to the over-immobilisation of patients [3,8-11]. In settings with strong for-profit health care services, the practice of financial medicine has been implicated as a factor contributing to overimmobilisation [12]. Furthermore, adverse events associated with SMR practices have been reported. These include, amongst others, prolonged scene time, increased pain, tissue breakdown, respiratory compromise and failed intubation, elevated intracranial pressure, pressure ulcers, disrupting physical examinations and ineffective immobilisation [5,13,14].

Literature suggests that appropriate prehospital selective SMR guidelines and decision tools can improve EMS practitioners' diagnostic abilities [6,15]. This offers several benefits to patient care, including decreased costs [16], reduction in over-immobilisation rates [9,16], decreased scene time [17] and allowing for more efficient use of valuable resources in resource-limited settings [9]. In addition, appropriate prehospital spinal immobilisation in cervical spine injury has been associated with favourable functional outcomes at discharge [13].

In South Africa, the National Emergency X-Radiography Utilization Study (NEXUS) [18] and the Canadian C-spine Rule (CCR) [19] decision tools have received considerable support for their use in the prehospital setting [20]. Therefore, it is important to identify system-specific barriers to and facilitators of these selective SMR decision support tools that may drive prehospital implementation. The current study presents a scoping review on clinical cervical spine clearance and selective SMR decision support tools to identify possible barriers to implementation, safety, and effectiveness when used by EMS practitioners.

Methods

The Arksey and O'Malley methodological framework [21] that suggests six stages for undertaking scoping reviews guided this study, and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews checklist was used to structure this report [22].

Identifying the research question

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

- Which clinical spinal clearance and/or 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 clinical spinal clearance and/or selective SMR decision support tools?
- What are the potential adverse events associated with using clinical spinal clearance and/or selective SMR decision support tools by EMS practitioners?

Search strategy and information sources

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

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((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])
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Search results were limited to those published in or after 2000 and available in English. During the full-text review, reference lists were

examined for further articles and these were also screened against the established inclusion and exclusion criteria (Figure 1).

Following the initial screening process (described below), we observed very limited literature (n=1) evaluating the use of selective SMR decision support tools in the prehospital setting. For this reason, we adjusted the search strategy to include first-line management of blunt trauma patients by medical practitioners in the emergency department (ED) and contextualised these findings to the prehospital setting, in accordance with scoping review methodology [23].

Screening and eligibility

In total, 541 titles and abstracts were screened and 152 articles were submitted to full-text review for screening against the inclusion and exclusion criteria (Figure 1). Studies were eligible for inclusion if they were published research articles describing the use of any clinical spinal clearance decision tool in the first-line management of adult, blunt trauma patients by medical practitioners in the ED or by EMS practitioners in a prehospital setting. This review included only studies describing the care of adult blunt trauma patients as the paediatric age group presents several challenges to the practice of immobilisation and the assessment of injury to the neck due to the unique anatomical, physiological and developmental characteristics of paediatric patients [24,25]. The age cut-off for management as an adult patient was determined by the clinical setting of the study under review. Exclusion criteria were: (i) articles not available in English, (ii) studies focused only on helicopter EMS (HEMS) settings as this population is unique [26], (iii) studies on the interfacility transfer of patients, and (iv) studies describing patients who sustained penetrating injuries since SMR may provide minimal benefit in treating these injuries, which are unlikely to cause instability [27], are associated with higher mortality [28,29] and increase the risk of deterioration [30]. Duplicate articles were removed, and article titles and abstracts were screened against eligibility criteria by one author [CG]. The title and abstract of potentially excluded articles were also reviewed by a second author [HM], who confirmed the screening, whilst the third author [CS] resolved any conflicts. The full text of articles identified in the screening step was reviewed against the inclusion and exclusion criteria by CG and HM, and CS resolved any conflicts.

Extracting and charting the data

Data were extracted and charted by CG according to a modified descriptive-analytical framework recommended by Arksey and O'Malley [21]. The abstraction tool was pre-tested on five articles. Following discussion, the abstraction tool was amended and additional information categories added. The following data were extracted: Study design; Intervention type and comparator (if any); Study aim; Study sample; Study context: prehospital / ED; Study outcomes; Setting: Country.

Thematic data analysis was applied as described by Levac, Colquhoun and O'Brien [23]. This 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 research questions. All terms related to SMR, or clinical spinal clearance decision tools, were collected under the study findings section (Table 1).

Results

Forty-two articles were identified and included in this scoping review (Table 1). The included articles were predominantly observational study designs and reviews (Table 2). Over a third (38%) of all studies included in this review presented findings or perspectives from the United States of America. The distribution of studies according to the country is shown in Table 2, and included no empirical studies performed in resource-limited settings.

Of the 42 articles included in this study, twenty-four articles (57%) evaluated the use of specific clinical spinal clearance and SMR deci-

Table 1

List of articles identified and included in the scoping review (N=42)

Author, year	Journal	Title	Study design	Study aim	Setting	Themes identified
Armstrong et al., 2007	Emergency Medical Journal	Prehospital clearance of the cervical spine: does it need to be a pain in the neck?	Cross-sectional	To determine whether the incidence of unnecessary C-spine immobilisation could be safely reduced by implementing an evidence-based algorithm.	Prehospital, United Kingdom	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient-centred selective SMR algorithm to minimise harms associated with SMR devices
Burton et al., 2006	Journal of Trauma	A statewide, prehospital emergency medical service selective patient spine immobilization protocol.	Retrospective chart review	To evaluate a statewide EMS protocol for trauma patient spine assessment and selective patient immobilisation	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-immobilisation
Burton et al., 2005	Prehospital Emergency Care	EMS provider findings and interventions with a statewide EMS spine-assessment protocol.	Prospective cohort study	To evaluate the implementation of prehospital spine-assessment protocol for EMS providers in a rural state.	Prehospital, United States of America, rural	
Domeier et al., 2002	Journal of Trauma	Multicenter prospective validation of prehospital clinical spinal clearance criteria	Prospective cohort study	To validate that the absence of five prehospital clinical criteria can be used to identify prehospital trauma patients without a significant spine injury.	Prehospital, United States of America	<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"> • Missed injury
Connor et al., 2013	Emergency Medical Journal	Prehospital immobilization: an initial consensus statement	Review (Consensus statement)	To review the evidence available on the practice of prehospital spinal immobilisation	Prehospital, United Kingdom	
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.	Prospective cohort study	To determine whether the use of an EMS protocol for selective spine immobilization results in appropriate immobilisation without spinal cord injury	Prehospital, United States of America	<i>Barrier:</i> <ul style="list-style-type: none"> • Lack of guideline compliance • Protocol misapplication/protocol violation <i>Adverse event:</i> <ul style="list-style-type: none"> • Missed injury
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 selective immobilization.	Retrospective chart review	To evaluate sensitivity and safety of an EMS selective spine immobilisation protocol in identifying patients with potential cervical injuries.	ED and Prehospital, United States of America	<i>Barrier:</i> <ul style="list-style-type: none"> • Lack of guideline compliance • Protocol miss/deficiency • Protocol misapplication/violation <i>Adverse event:</i> <ul style="list-style-type: none"> • Missed injury
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 prehospital setting for patients with potential SCI.	Prehospital, Non-specific	<i>Barrier:</i> <ul style="list-style-type: none"> • Lack of guideline compliance

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Table 1 (continued)

Author, year	Journal	Title	Study design	Study aim	Setting	Themes identified
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 traumatic SCI and the practice of prehospital spinal immobilisation.	Prehospital, Non-specific	
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.	ED, Canada	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Development and adoption of context fit decision tool criteria • Well established and comprehensive implementation approach based on behavioural change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Variation of guideline utilisation • Protocol misapplication
Vaillancourt et al., 2009	Annals of Emergency Medicine	The out-of-hospital validation of the Canadian C-spine rule by paramedics.	Prospective cohort study	To assess the performance characteristics, reliability, and suitability of the CCR when used by paramedics in the prehospital setting.	Prehospital, Canada	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Protocol misapplication
Gonzalez et al., 2013	American Surgeon	Prehospital clinical clearance of the cervical spine: a prospective study.	Prospective cohort study	To assess whether EMS practitioners can effectively clinically clear the C-spine of blunt trauma injured patients.	Prehospital, United States of America (urban)	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Lack of guideline compliance
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 practice in the emergency department.	Cross-sectional study	To identify potential facilitators and barriers to an implementation policy that would allow nurses to clear the C-spine of minor trauma patients clinically.	ED, Canada	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Well established and comprehensive implementation approach based on behavioural change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Lack of guideline compliance
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 validate the sensitivity of a selective prehospital immobilisation protocol.	Prehospital, Netherlands	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> • Criterion modification
Kreinst et al., 2017	European Journal of Trauma Emergency Surgery	Expertise of German paramedics concerning the prehospital treatment of patients with spinal trauma.	Cross-sectional study	To analyse German paramedics' subjective uncertainty in terms of their prehospital assessment and treatment of patients suffering from spine injuries.	Prehospital, Germany	<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
Larson et al., 2018	Journey of Emergency Nursing	The use of clinical cervical spine clearance in trauma patients: a literature review.	Systematic review	To review the available evidence on the risks associated with cervical collars and clinical clearance of C-spine immobilisation precautions in trauma patients.	ED/Facility, Non-specific	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> • Lack of guideline compliance <p><i>Adverse event:</i></p> <ul style="list-style-type: none"> • Over-immobilisation

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Table 1 (continued)

Author, year	Journal	Title	Study design	Study aim	Setting	Themes identified
Clement et al., 2016	International Emergency Nursing	Facilitators and barriers to application of the Canadian C-spine rule by emergency department triage nurses.	Cross-sectional study	To evaluate nurses, physicians and administrators views on the facilitators and barriers to the implementation of the CCR.	ED, Canada	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioural change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> Lack of guideline compliance Protocol misapplication
Fontaine et al., 2018	Journal of Emergency Nursing	Cervical spine collar removal by emergency room nurses: a quality improvement project.	Practice improvement project	To train ED nurses in the use of CCR; To monitor use throughout the project; To compare the assessment of nurses using the CCR with assessments by emergency physicians.	ED, Canada	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioural change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> Protocol misapplication Lack of guideline compliance
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 interventions to reduce C-spine imaging in adults presenting with neck trauma.	ED, Non-specific	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioural change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> Lack of guideline compliance
Myers et al., 2009	International Journal of Emergency Medicine	Efficacy and compliance of a prehospital spinal immobilization guideline.	Retrospective cohort study	To examine the efficacy of a prehospital spinal clearance guideline in triage/management of these injuries.	ED and Prehospital, United States of America.	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> Criteria medication <p><i>Barrier:</i></p> <ul style="list-style-type: none"> Lack of guideline compliance <p><i>Adverse event:</i></p> <ul style="list-style-type: none"> Missed injury
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 evaluate and improve the documentation of C-spine clearances by standardising the confrontational spine examination for patients sustaining blunt trauma.	ED, United States of America	<p><i>Facilitator:</i></p> <ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioural change theory <p><i>Barrier:</i></p> <ul style="list-style-type: none"> Lack of guideline compliance

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Table 1 (continued)

Author, year	Journal	Title	Study design	Study aim	Setting	Themes identified
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 (Consensus statement)	To review the evidence base and develop a practice guideline for the prehospital management of adult trauma patients with a potential spinal injury.	Prehospital, Norway	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient-centred selective SMR algorithm which goal is to minimise harms associated with SMR devices
Kreinst et al., 2016	Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine	Development of a new emergency medicine spinal immobilization protocol for trauma patients and a test of applicability by German emergency care providers.	Cross-sectional study	To develop a protocol that supports decision-making for SMR in adult trauma patients; To carry out an applicability test by emergency care providers.	Prehospital, Germany	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient-centred selective SMR algorithm which goal is to minimise harms associated to SMR devices
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 assessing prehospital selective immobilisation protocols across a range of outcomes.	Prehospital, Non-specific	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient-centred selective SMR algorithm which goal is to minimise harms associated to SMR devices <i>Barrier:</i> <ul style="list-style-type: none"> • Protocol miss/deficiency <i>Adverse event:</i> <ul style="list-style-type: none"> • Missed injury
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 update findings of the 2000–2010 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.	Non-specific	<i>Facilitator:</i> <ul style="list-style-type: none"> • Well established and comprehensive implementation approach based on behavioural change theory <i>Barrier:</i> <ul style="list-style-type: none"> • Protocol misapplication • Lack of guideline compliance
Castro-Marin, 2020	Prehospital Emergency Care	Prehospital protocols reducing long spinal board use are not associated with a change in incidence of spinal cord injury.	Retrospective chart review	To determine if implementation of SMR protocols, which reduce long spine board use, was associated with an increase in SCI	ED and Prehospital, United States of America	
Hauswald and Braude, 2002	Current Opinion in Critical Care	Spinal immobilization in trauma patients: is it really necessary?	Review	To review the evidence on minimising harm from both under- and over-immobilisation in trauma patients.	Non-specific	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient-centred selective SMR algorithm which goal is to minimise harms associated to SMR devices
Dunn et al., 2004	Prehospital Emergency Care	Are emergency medical technician-basics able to use a selective immobilization of the cervical spine protocol? A preliminary report.	Cross-sectional study	To determine whether basic emergency medical technicians can use a protocol that allows for selective immobilisation of the cervical spine.	Prehospital, United States of America	<i>Facilitator:</i> <ul style="list-style-type: none"> • Patient-centred selective SMR algorithm which goal is to minimise harms associated with SMR devices

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Table 1 (continued)

Author, year	Journal	Title	Study design	Study aim	Setting	Themes identified
						<ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioural change theory Development and adoption of context fit decision tool criteria <p><i>Barrier:</i></p> <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
Collins et al., 2013	European Journal of Emergency Medicine	The NEXUS criteria: do they stand the test of time?	Case series	Presents a case series report on three elderly patients who would not have warranted C-spine imaging using NEXUS criteria.	ED, 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
Hankins et al., 2001	Prehospital Emergency Care	Spinal immobilization in the field: clinical clearance criteria and implementation.	Consensus statement	To review the evidence to discuss controversies in SMR.	ED and Prehospital, Non-specific	
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 with respect to the proportion of patients who would require cervical SMR and the number of missed cervical spine injuries.	Prehospital United States of America, urban	<p><i>Barrier:</i></p> <ul style="list-style-type: none"> Lack of guideline compliance
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 statement)	To review the literature on prehospital procedures for spinal stabilisation of adult trauma patients in Denmark.	Prehospital, Denmark	<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
Oteir et al., 2017	Prehospital Emergency Care	Prehospital predictors of traumatic spinal cord injury in Victoria, Australia.	Retrospective cohort study	To identify the prehospital predictors of traumatic SCI and describe the differences between confirmed and potential traumatic SCI cases.	ED 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

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Table 1 (continued)

Author, year	Journal	Title	Study design	Study aim	Setting	Themes identified
Cacho García et al., 2019	International Journal of Critical Care and Emergency Medicine	Efficacy of cervical immobilisation in multiple trauma patients.	Review	To review the literature on effectiveness of immobilisation in multiple trauma patients.	Non-specific	<i>Facilitator:</i> <ul style="list-style-type: none"> Development and adoption of context fit decision tool criteria
Sebastian et al., 2001	California Journal of Emergency Medicine	EMS Adherence to a prehospital cervical spine clearance protocol	Retrospective descriptive study	To determine the degree of adherence to a C-spine clearance protocol by prehospital EMS practitioners To describe protocol deviations To determine if the rate of compliance by paramedic self-assessment differed from receiving hospital assessment.	ED and Prehospital, United States of America.	<i>Facilitator:</i> <ul style="list-style-type: none"> Well established and comprehensive implementation approach based on behavioural change theory <i>Barrier:</i> <ul style="list-style-type: none"> Lack of guideline compliance
Paterek et al., 2015	Spine	Characteristics of trauma patients with potential cervical spine injuries under immobilised by prehospital providers.	Retrospective chart review	To determine the characteristics of patients under-immobilised by prehospital providers.	ED 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-immobilisation
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 determine the sensitivity and specificity of a prehospital spinal clearance protocol.	ED and Prehospital, United States of America.	
Underbrink et al., 2018	Prehospital Emergency Care Journal	New immobilisation guidelines change EMS critical thinking in older adults with spine trauma.	Retrospective Chart Review	To determine whether a prehospital protocol would alter immobilization methods and affect patient outcomes among adults ≥60 years with a cervical spine injury.	ED and Prehospital, United States of America.	<i>Facilitator:</i> <ul style="list-style-type: none"> Development and adoption of context fit decision tool criteria
Pitt et al., 2006	Emergency Medical Journal	Removal of C-spine protection by A&E triage nurses: a prospective trial of a clinical decision-making instrument.	Prospective cohort study	To determine whether triage nurses could safely apply a set of clinical criteria, removing hard collars and spinal boards at initial triage assessment.	ED, Scotland	
Fischer et al., 2018	Prehospital Emergency Care	Spinal motion restriction in the trauma patient – a joint position statement.	Consensus statement	To review the evidence and provide updated guidance on the practices of SMR in trauma patients	Non-specific, United States of America	<i>Facilitator:</i> <ul style="list-style-type: none"> Patient-centred selective SMR algorithm which goal is to minimise harms associated with SMR devices
Coggins et al., 2019	Australasian Emergency Care	A prospective evaluation of cervical spine immobilisation in low-risk trauma patients at a tertiary emergency department.	Prospective cohort study	To describe practices and rate of concordance with established international guidelines.	ED, Australia	<i>Facilitator:</i> <ul style="list-style-type: none"> Patient-centred selective SMR algorithm which goal is to minimise harms associated to SMR devices <i>Barrier:</i> <ul style="list-style-type: none"> Lack of guideline compliance
Stanton et al., 2017	African Journal of Emergency Medicine	Cervical collars and immobilisation: a South African best practice recommendation	Review	To provide a contextualised best practice recommendation for protection of the spine during transport	Prehospital, South Africa	

Abbreviations: CCR: Canadian C-spine Rule; C-spine: Cervical spine; EMS: Emergency Medical Service; ED: Emergency Department; NEXUS: National Emergency X-Radiography Utilization Study; SCI: Spinal Cord Injury; SMR: Spinal motion restriction;

Table 2
Summary of information charted for included articles (N=42).

Characteristics	Frequency n (%)	
Study design (N=42)	Retrospective cohorts and chart reviews	11 (26)
	Cross-sectional studies	7 (17)
	Prospective cohort studies	7 (17)
	Systematic Reviews	7 (17)
	Reviews	5 (12)
	Non-systematic consensus statements	3 (7)
	Case series	1 (2)
	Practice improvement project	1 (2)
	Clinical spinal clearance and SMR decision support criteria (N=24)	
NEXUS	In-hospital	2 (8)
	Pre-hospital	0 (0)
CCR	In-hospital	2 (8)
	Pre-hospital	1 (4)
Other	In-hospital	1 (4)
	Prehospital	18 (75)
Country setting (N=42)	United States of America	16 (38)
	Non-specific	9 (21)
	Canada	5 (12)
	Australia	2 (5)
	Germany	2 (5)
	United Kingdom	2 (5)
	Denmark	1 (2)
	Ireland	1 (2)
	Netherlands	1 (2)
	Norway	1 (2)
	Scotland	1 (2)
	South Africa	1 (2)
	Barriers identified (N=23)	Lack of guideline compliance
Protocol misapplication/ protocol violation		8 (35)
Protocol miss/ Protocol Deficiency		6 (26)
Variation of guideline utilisation		1 (4)
Patient-centred selective SMR algorithm which goal is to minimise harms associated with SMR devices.		10 (40)
Facilitators identified (N=25)	Well established and comprehensive implementation approach based on behavioural change theory.	9 (36)
	Development and adoption of context fit decision tool criteria.	5 (20)
	Criterion modification.	2 (8)

CCR: Canadian C-spine Rule; NEXUS: National Emergency X-Radiography Utilization Study; SMR: Spinal motion restriction.

sion support tools (Table 2) [6,16,17,31-51]. Two of these studies (8%) evaluated the effectiveness and safety of combining NEXUS-based criteria with some CCR criteria elements [17,38]. Six studies (25%) evaluated the use of NEXUS-based protocols [16,35,40-42,47]. Just under half (46%) of the studies identified other SMR decision making criteria developed from consensus meetings and published systematic reviews [6,33-36,39,43,45,48-50].

A total of 25 articles (60%) described potential facilitators [6,9,17,31,32,36,41,42,44-48,50,52-62] and 23 articles (55%) described potential barriers [16,32-34,38-40,42-47,50-53,55,58,60-62,70] to the use and effectiveness of SMR decision support tools (Table 2).

Discussion

This scoping review found limited literature evaluating the use of either the NEXUS or CCR decision tools in the prehospital setting. As a result, its safety and effectiveness when used by EMS practitioners could not be determined [63]. We, therefore, contextualised the findings from facility-based studies to the prehospital setting. This review commonly found NEXUS-based decision tools being utilised by EMS practitioners. Several potential facilitators and barriers to the effectiveness of SMR decision support tools were identified, the most prevalent of which are briefly discussed below.

Terminology

Two key issues related to terminology were identified as potential barriers to use in the prehospital setting. The terms '*clinical spine clearance*' and '*selective spinal motion restriction*' were often used interchangeably [27]. Whilst Hauswald and Braude [64] suggest that the difference between these two terms is not clear, Quinn et al. [65] 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.

Based on the principle that the CCR and NEXUS decision tools were developed to facilitate selective cervical spine radiography and expedite exclusion of cervical injury in patients in the hospital setting [18,19,51], we found it appropriate to classify these decision tools as clinical cervical spine clearance tools. A selective SMR decision tool is a careful approach to the use of various SMR methods. These include manual in-line stabilisation or full-motion restriction [59] in the management work up, packaging, extrication and transportation of patients [49]. Moreover, selective SMR decision making facilitates the consideration of specific clinical criteria, which leads to the selective exclusion of patients from full-motion restriction [50], thereby reducing the rate of unwarranted SMR, minimising adverse effects and harms [27,66-69]. Such a decision tool can be considered patient-centred in the prehospital setting.

With this distinction in mind, this review found only one study that examined the implementation of a clinical c-spine clearance tool, the

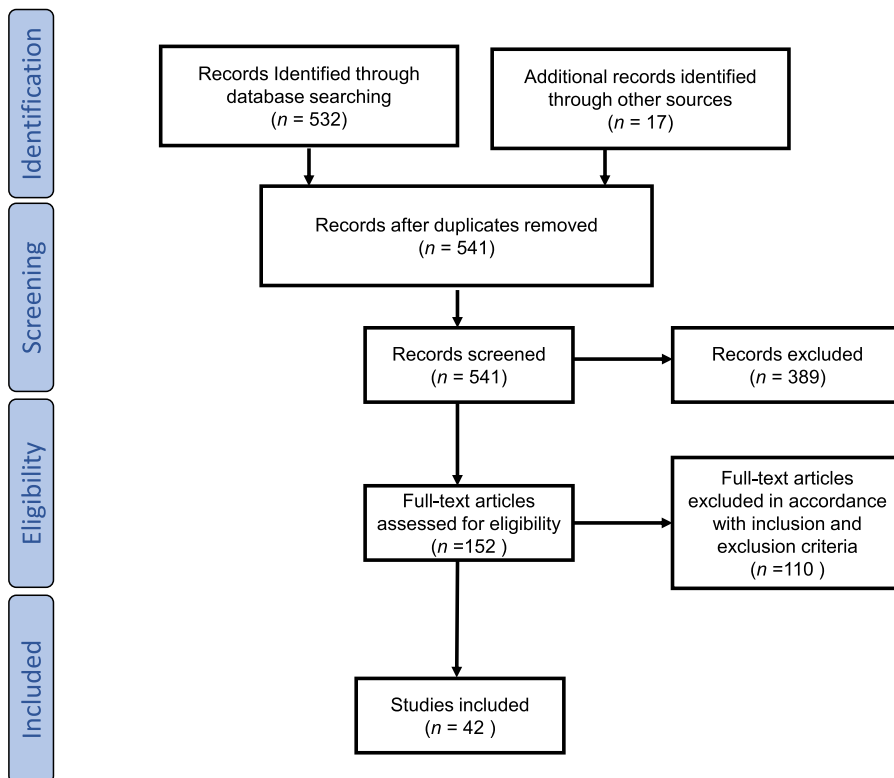


Fig. 1. Prisma diagram describing screening and selection of articles for review.

CCR, in the prehospital setting [44]. The remainder of the articles examined clinical cervical spine clearance tools' effectiveness when used by ED staff [32,37,46,51]. Because of the limited availability of supporting studies in the prehospital setting and the skillset of EMS practitioners varies by region [33], it is unclear from this review whether clinical c-spine clearance tools can be effectively implemented in the resource-constrained prehospital setting.

An important difference between the two terms and the context of use should be considered. Over-immobilisation is a documented adverse event in using spinal assessment decision tools. Over-immobilisation may stem from the fear of legal litigation if a severe injury (unstable fracture) is missed [31,38,53]. 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 be indisputably achieved in the prehospital setting.

Barriers to the effective implementation of SMR decision support tools

Lack of assessment or guideline compliance was viewed as a general adverse event that often resulted in missed injury [16,32-34,38-40,42,43,45-47,50,52,53,55,58,61,70]. This was attributed to several barriers, missing or sporadic documentation and reporting on the decision for or against SMR [38,39]. Missing information on PRD will cause further challenges in quality assurance measures, such as monitoring the rate of compliance with SMR guidelines [45] and may also have legal ramifications [52]. Therefore, EMS implementation strategies and plans should value incorporating ways to avoid the adverse events stemming from this barrier.

Protocol misapplication where criteria were present, but no SMR was attempted by EMS [44,45,62] also contributed to the theme of noncompliance. This may be attributed to the poor general applicability of the decision tool by EMS, as criteria definitions were interpreted differently [33,38,40,43-45,47,60].

Paramedics were also more conservative than their emergency physician counterparts in applying criteria, which often led to over-

immobilisation [16,60]. This practice increases the possibility of creating false-positive cases when the patient arrives at the hospital [50]. Two main contributing factors can be attributed to this barrier; first, providers fear missing injuries and litigation [32,38,46,53]. Second, providers are not comfortable performing a criterion such as asking the patient to rotate their neck [32,44]. The latter may be further attributed to provider doubts about the merit of an SMR decision support tool and their subsequent apprehension about its application in clinical practice [32]. Although not explicitly identified in the current review, another factor that may contribute to over-immobilisation is the practice of financial medicine in the for-profit sector [12]. In South Africa, for example, Vincent-Lambert and Jackson (2016) previously reported that calls are often falsely upgraded by deliberately performing clinical interventions that are not clinically indicated, allowing service providers to bill at a higher rate [12].

Facilitators of the effective implementation of SMR decision support tools

Published literature suggests that developing and implementing a selective SMR guideline that is patient-centred and guides the tailored use of equipment will be beneficial [17,29,38,48,50,54,56,57,62,64]. This decision tool will aid in minimising immobilisation delays in critically ill patients and may also minimise the harms associated with SMR devices. A patient-centred SMR tool may provide a standardised approach to providers, minimising provider variability, and facilitate the monitoring of guideline compliance [52,55,57]. This was seen as an important facilitator to the effectiveness of SMR decision support tools.

When introducing new decision tools within the prehospital EMS field, strategies for implementing them into regular practice are crucial to facilitate effectiveness, and this study identified implementation approaches based on behavioural change theory as a facilitator. Published literature highlights the need for purposeful directives to change institutional culture and mindset before implementation [38,52]. Because of this, a well-established and multifaceted implementation strategy based on behavioural change theory may be beneficial

[32,34,38,46,50,52,53,60,61]. These may increase provider adherence and decision tool fidelity, decreasing overimmobilisation rates [34].

Although several protocols that allow for selective SMR practice have been implemented in the prehospital environment, literature that explicitly investigates the effectiveness and safety of spinal clearance in the prehospital setting is limited [63]. The safety of spinal clearance protocols depends critically on the accuracy and appropriateness of their application [67]. The development of context fit decision tool criteria for the prehospital setting was therefore identified as a potential facilitator to effective implementation. A blanket approach to spinal precautions within the prehospital setting may be challenging, especially in settings where the EMS qualification landscape is very diverse. In South Africa, for example, there are seven different registerable EMS qualifications ranging from historical, short course certifications to degree qualifications [71]. Variability in skills and knowledge may be a confounding factor [67] when extrapolating results from other settings.

Considering recommendations for the use of either NEXUS or CCR [20], we found it relevant to investigate the skill and knowledge level needed for the appropriate, safe and practical application of the respective criteria as it may lead to missed injuries [72]. 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, recognise the importance of the mechanism of injury (MOI), and perform an adequate evaluation of the patient to ensure that nothing is missed [73]. 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 ED disciplinary levels, where some concerns were documented [58]. The most significant concern is that the individual components introduce substantial subjectivity to the rule [58,75]. As a result, the interpretation is subject to variability [69].

Upon further examination of the literature, we observed that SMR decision tools that incorporate and modify the NEXUS criteria and CCR are commonly found [6,33]. These modifications may have been incorporated to address the documented challenges when using the NEXUS and CCR criteria and increase its sensitivity in the prehospital setting [6,33]. Several studies have demonstrated that EMS practitioners can use NEXUS-based decision tools to inform them of which patients can forgo SMR [41,45,49,64,75]. However, some studies have shown that modified criteria used to increase prehospital sensitivity present with certain challenges [45,48,67,74,76,77]. One such challenge is a poor interrater agreement when assessing individual clearance criteria such as distracting injury, neck pain or tenderness, neurological deficit, and neck pain with motion [67]. There is also a concern for the reliability of detecting spinal injury in the elderly population group (≥ 65 years) when using NEXUS-based protocols, which incorporate a clinical assessment component considering the MOI [48,74]. Because of the older population's skeletal fragility [76], they are more often subject to cervical spine injury from lower force MOI, such as ground-level falls, which would be considered NEXUS negative [74]. Thus, older age should be considered an independent risk factor for cervical spine injury in blunt trauma [45,74,77].

Considering these opposing views, more studies are needed to assess the safety, efficacy, and effectiveness of clinical spine clearance and NEXUS-based decision tools in the prehospital setting [78]. 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.

Future directions

Prehospital SMR decision tools have the stated aim of reducing unnecessary SMR and its associated adverse effects while protecting patients with injuries from further harm [62]. In the low resource setting, it is essential to carefully consider who requires SMR and which SMR methods are context-appropriate. More importantly, to consider which

systems may potentially stand in the way of providing optimal patient care to trauma patients. Furthermore, developing a spinal management strategy that incorporates criteria appropriate for the prehospital setting into a decision tool for selective SMR is of value. This is particularly true for settings, such as South Africa, with a diverse array of EMS qualifications in terms of practitioners' scope, knowledge, and experience. These instructions should specifically minimise patient harm associated with both over- and under-immobilisation [64]. This may be achieved through an SMR algorithm which provides the practitioner with differential treatment considerations. More specifically, it is believed that an SMR algorithm that considers the setting, skills, EMS practitioners' capability, availability of equipment, and patient condition will be of value in this regard. Several studies in this review have already designed such tools with these factors in mind [29,48,49,56,59]. It is, therefore, important that future research on prehospital selective SMR practices builds on the evidence found in this scoping review.

Study limitations

Studies not published in English were excluded, and therefore important literature relevant to the topic may have been missed. Since this was not a systematic review or a meta-analysis, the strength and validity of studies included in this scoping review were not formally determined. In addition, data extraction was completed primarily by a single author which may have introduced bias in the categorisation of the data. The paucity of literature evaluating the use of selective SMR decision support tools in the prehospital setting is a further limitation to the study.

Conclusion

Only one study was found investigating the effectiveness and safety of spinal clearance decision tools, CCR or NEXUS criteria, in the prehospital setting. However, NEXUS-based decision tools are commonly used by prehospital practitioners. Both these decision tools present unique setting specific challenges. Therefore, little value may be found in extrapolating results from other settings to low resource settings. More studies are needed to develop and implement context fit, patient-centred, selective SMR decision tools that may be valuable in prehospital settings such as South Africa. Furthermore, it is believed that a selective SMR decision tool with more specific instructions for prehospital practitioners is an area that needs further investigation. This scoping review provides the basis for future research in this field.

Dissemination of results

No patient data were collected in this study and findings have not been disseminated within any patient community.

Authors' contribution

Authors contributed as follows to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting or revising it critically for important intellectual content: CG contributed 50%; HM 25%; and CS 25%. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interest

The authors declare no conflict of interest

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