

Perceptions and use of the vacuum mattress in prehospital trauma care: a cross-sectional survey

Percezioni e utilizzo del materasso a depressione nell'assistenza traumatologica preospedaliera: un'indagine trasversale

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ABSTRACT

Introduction: spinal immobilization has traditionally been considered a key component of prehospital trauma care to prevent secondary spinal cord injury. However, growing evidence has questioned the routine use of rigid immobilization such as spine board, highlighting potential complications and limited clinical benefit. In response, the concept of spinal motion restriction has been introduced, promoting more selective approaches to spinal stabilization. Despite evolving recommendations, variability in clinical practice persists, and the perceptions and decision-making processes of prehospital providers regarding immobilization devices remain poorly explored.

Materials and Methods: a cross-sectional observational survey was conducted among prehospital healthcare professionals operating within the emergency medical services system of Azienda USL Toscana Centro, Italy. A structured questionnaire consisting of 15 multiple-choice items was developed to assess knowledge, perceptions, and reported practices regarding the use of spinal immobilization devices, with particular focus on the vacuum mattress. Responses were collected anonymously through an online survey platform and analyzed using descriptive statistics.

Results: a total of 86 prehospital professionals participated in the survey, including nurses (22.1%) and advanced rescuers (77.9%). While the vacuum mattress was perceived by 74.4% of respondents as the most effective immobilization device, the spine board was considered the fastest device by 82.6%. Despite this perceived effectiveness, the vacuum mattress appeared to be rarely used in clinical practice, with 94.2% of participants reporting fewer than five uses per year.

Conclusions: a discrepancy exists between participants' perceived effectiveness and the actual use of spinal immobilization devices in prehospital trauma care. Operational factors such as application speed, provider familiarity, and logistical considerations may influence device selection. Improving training and aligning clinical practice with evolving SMR recommendations may support more consistent and evidence-informed trauma care.

Key words: emergency medical services; wounds and injuries; spinal injuries; immobilization; vacuum mattress.

RIASSUNTO

Introduzione: l'immobilizzazione spinale è stata tradizionalmente considerata una componente fondamentale dell'assistenza traumatologica preospedaliera per prevenire lesioni secondarie al midollo spinale. Tuttavia, prove sempre più numerose hanno messo in discussione l'uso di routine di metodi di immobilizzazione rigidi, come la tavola spinale, evidenziandone le potenziali complicanze e i benefici clinici limitati. In risposta a ciò, è stato introdotto il concetto di limitazione del movimento spinale, che promuove approcci più selettivi alla stabilizzazione della colonna vertebrale. Nonostante l'evoluzione delle raccomandazioni, persiste una variabilità nella pratica clinica e le percezioni e i processi decisionali degli operatori preospedalieri riguardo ai dispositivi di immobilizzazione rimangono poco studiati.

Materiali e Metodi: è stata condotta un'indagine osservazionale trasversale tra gli operatori sanitari preospedalieri che operano nell'ambito del sistema dei servizi medici di emergenza dell'Azienda USL Toscana Centro, in Italia. È stato sviluppato un questionario strutturato composto da 15 domande a scelta multipla per valutare le conoscenze, le percezioni e le pratiche riportate relative all'uso dei dispositivi di immobilizzazione spinale, con particolare attenzione al materasso a depressione. Le risposte sono state raccolte in forma anonima tramite una piattaforma di sondaggi online e analizzate utilizzando statistiche descrittive.

Risultati: hanno partecipato al sondaggio un totale di 86 professionisti del settore preospedaliero, tra cui infermieri (22,1%) e soccorritori avanzati (77,9%). Mentre il materasso a depressione è stato percepito dal 74,4% degli intervistati come il dispositivo di immobilizzazione più efficace, la tavola spinale è stata considerata il dispositivo più veloce dall'82,6%. Nonostante questa percezione di efficacia, il materasso a depressione sembrava essere utilizzato raramente nella pratica clinica, con il 94,2% dei partecipanti che riferiva meno di cinque utilizzi all'anno.

Conclusioni: esiste una discrepanza tra l'efficacia percepita dai partecipanti e l'uso effettivo dei dispositivi di immobilizzazione spinale nell'assistenza traumatologica preospedaliera. Fattori operativi quali la rapidità di applicazione, la familiarità degli operatori e considerazioni logistiche possono influenzare la scelta del dispositivo. Migliorare la formazione e allineare la pratica clinica alle raccomandazioni in continua evoluzione della SMR potrebbe favorire un'assistenza traumatologica più coerente e basata sull'evidenza.

Parole chiave: emergenza sanitaria territoriale; trauma; lesioni spinali; immobilizzazione spinale; materasso a depressione.

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Introduction

Traumatic injuries represent a major global health challenge and remain a leading cause of death and disability worldwide, particularly among young adults. Early prehospital management plays a critical role in reducing mortality and preventing secondary complications. Emergency Medical Services (EMS) providers are therefore required to rapidly assess trauma patients and implement appropriate stabilization strategies before hospital arrival.¹ Spinal protection has traditionally been regarded as a cornerstone of prehospital trauma care. Since the 1960s, suspected spinal injuries have commonly been managed through the routine application of rigid cervical collars and spine boards to minimize spinal movement and prevent secondary neurological injury.² However, the evidence supporting routine spinal immobilization has increasingly been questioned. Several studies have reported uncertain clinical benefits while highlighting potential complications associated with rigid immobilization, including pain, pressure injuries, respiratory impairment, delayed airway management, and increased intracranial pressure.^{2,3} These concerns have contributed to a gradual shift from routine spinal immobilization toward the concept of Spinal Motion Restriction (SMR), which aims to minimize unnecessary spinal movement while avoiding potentially harmful interventions. Accordingly, a joint position statement from major trauma and emergency medicine organizations emphasized that true immobilization cannot be achieved in the prehospital setting and that management should instead focus on limiting spinal motion while prioritizing overall patient care.⁴ In parallel with this conceptual evolution, increasing attention has been directed toward the performance of different stabilization devices used in prehospital trauma care. Various devices, including spine boards, vacuum mattresses, and scoop stretchers, are commonly employed depending on local protocols and operational contexts. Biomechanical and simulation studies have produced heterogeneous findings regarding their performance. For example, experimental analyses of cervical spine motion during ambulance transport have suggested that different immobilization techniques may provide variable levels of motion restriction depending on device configuration and clinical circumstances.⁵ Operational factors also influence device selection in the prehospital environment. Time-critical scenarios may favor devices that allow faster stabilization and rapid patient transport, whereas others may provide greater comfort or stabilization at the expense of longer application times.^{6,7} Consequently, despite the growing body of literature on spinal stabilization techniques, considerable variability persists in clinical practice, with immobilization strategies often influenced by local protocols, provider experience, and operational constraints rather than standardized evidence-based approaches.³ Although many studies have evaluated the biomechanical performance or clinical outcomes of different stabilization devices, relatively little attention has been paid to prehospital providers' knowledge, perceptions, and decision-making processes. Understanding these factors may help identify barriers to the implementation of evidence-based SMR strategies and explain potential discrepancies between current evidence and clinical practice. The aim of this study was to assess the knowledge, perceptions, and reported practices regarding the use of immobilization devices, with particular focus on the vacuum mattress, among prehospital providers operating within a regional emergency medical system.

Materials and Methods

Study design and participants

A cross-sectional observational survey was conducted to assess the knowledge and reported practices regarding the use of the vacuum mattress in prehospital trauma care among healthcare professionals involved in EMS. The study was carried out within the prehospital emergency system of Azienda USL Toscana Centro, one of the largest regional emergency service providers in central Italy. The Italian prehospital emergency medical system is organized at a regional level, resulting in variability in workforce composition and operational models across the country. Within the EMS system of Tuscany, prehospital emergency response is provided through a combination of healthcare professionals and volunteer-based emergency organizations integrated into the regional 118 network. In this context, advanced rescuers are volunteer emergency responders who have completed specific training programs delivered by accredited emergency organizations and have obtained certification allowing them to participate in prehospital emergency ambulance operations within the regional EMS system. Following theoretical and practical training, including supervised field experience, they are authorized to perform predefined emergency care activities according to regional protocols and under the organizational framework of the EMS network. Two professional groups involved in prehospital emergency care were targeted: EMS nurses working within the regional 118 prehospital emergency system and advanced rescuers operating in volunteer-based emergency organizations integrated within the same EMS network. Participants were eligible if they were actively involved in prehospital emergency response and had professional roles requiring the use of immobilization devices during trauma management. Individuals were included if they were EMS nurses or certified advanced rescuers working within the regional prehospital emergency system and provided informed consent to participate in the study. Participants who were not actively involved in prehospital emergency activities or who did not provide consent were excluded.

Survey development and data collection

A structured questionnaire was developed to investigate participants' knowledge and reported practices regarding the use of the vacuum mattress in prehospital trauma care. The questionnaire was developed by the study team based on current regional prehospital trauma management protocols and the available scientific literature on spinal motion restriction and immobilization practices. The questionnaire consisted of 15 single-response multiple-choice items organized into two sections addressing demographic and professional characteristics as well as knowledge and practical aspects related to the use of immobilization devices in trauma management. The complete questionnaire is provided as Supplementary Material 1 and corresponds to the version used for data collection. Prior to dissemination, authorization to conduct and distribute the survey was obtained from the Task Force of the Department of Nursing and Midwifery Care (DAIO) of Azienda USL Toscana Centro. Participation was voluntary and anonymous, and completion of the questionnaire was considered indicative of informed consent to participate. The survey was disseminated through institutional communication channels within the prehospital emergency service. EMS nurses received the questionnaire via internal email communication, while volunteer-based emergency organizations distributed the survey link among advanced rescuers through their internal communication networks. Responses were collected anonymously.

Statistical analysis

Survey responses were exported and analyzed using Jamovi. Descriptive statistics were used to summarize participants' demographic and professional characteristics as well as their responses to the questionnaire. Results were presented using tables and graphical representations to illustrate the distribution of responses within the study sample.

Results

Participant characteristics

A total of 86 prehospital professionals completed the survey. The majority of respondents were advanced rescuers (77.9%), while 22.1% were EMS nurses. Regarding professional experience, 32.6% of participants reported 1–5 years of service, 24.4% had 6–10 years, 29.1% had 11–20 years, and 14% reported more than 20 years of experience. Participant characteristics are summarized in Table 1.

Knowledge and decision-making in trauma immobilization

Most respondents reported that they would use a vacuum mattress for suspected pelvic fracture in the absence of other devices (87.2%), while 12.8% indicated they would not adopt this strategy. Similarly, 75.6% of participants reported that they would use a spine board in the same clinical scenario.

When asked about the most appropriate immobilization strategy in suspected cranial or spinal trauma, responses were almost evenly distributed between cervical collar combined with spine board (48.8%) and cervical collar combined with vacuum mattress (47.7%), while only a small proportion of respondents selected alternative strategies. In a thoracic trauma scenario, 54.7% of respondents reported that they would use a spine board, whereas 45.3% indicated they would avoid this device. Considerable

variability also emerged in the management of minor trauma scenarios. In the case of a patient presenting after a fall from less than one meter without pain, 37.2% of respondents reported they would apply only a cervical collar, 31.4% would use no immobilization device, and 27.9% would use a spine board, while only 3.5% selected the vacuum mattress. Detailed responses are reported in Table 2.

Perceptions and use of immobilization devices

Participants' perceptions regarding immobilization devices revealed a clear distinction between speed and perceived effectiveness. The spine board was perceived as the fastest device for immobilization by 82.6% of respondents, whereas the vacuum mattress was perceived by 74.4% of participants as the most effective device for patient stabilization. Despite this perceived effectiveness, the vacuum mattress appeared to be infrequently used in clinical practice. Most respondents (94.2%) reported using the device fewer than five times per year, while only a small proportion indicated more frequent use. These findings are summarized in Table 3.

Table 1. Participant characteristics (n = 86).

Characteristic	n	%
Professional role		
Advanced rescuer	67	77.9
EMS nurse	19	22.1
Years of service		
1- years	28	32.6
6-10 years	21	24.4
11-20 years	25	29.1
>20 years	12	14

Table 2. Knowledge, clinical decisions and perceptions regarding spinal immobilization devices.

Survey item	Response	n	%
Use of vacuum mattress for suspected pelvic fracture (no other devices available)	Yes	75	87.2
	No	11	12.8
Use of spine board for suspected pelvic fracture	Yes	65	75.6
	No	21	24.4
Spine immobilization strategy for suspected cranial/spinal trauma	Cervical collar + spine board	42	48.8
	Cervical collar + vacuum mattress	41	47.7
	Other strategies	3	3.5
Use of spine board in thoracic trauma	Yes	47	54.7
	No	39	45.3
Management of fall <1 m without pain	Spine board	24	27.9
	Cervical collar only	32	37.2
	Vacuum mattress	3	3.5
Perceived fastest immobilization device	No immobilization device	27	31.4
	Spine board	71	82.6
	Vacuum mattress	15	17.4
Perceived most effective device	Vacuum mattress	64	74.4
	Spine board	22	25.6
Frequency of vacuum mattress use per year	0–5 times	81	94.2
	6–10 times	4	4.7
	>10 times	1	1.1

Discussion

The present study explored prehospital providers' knowledge, perceptions, and practices regarding spinal immobilization devices, with particular focus on the use of the vacuum mattress. Our findings reveal a discrepancy between participants' perceived effectiveness of immobilization devices and their actual clinical use. While most participants perceived the vacuum mattress the most effective immobilization device, the spine board was perceived as faster to apply and remained more commonly used in clinical practice. Moreover, the vacuum mattress was reported to be used only rarely by most providers.

This perception–practice gap suggests that operational factors such as application speed, familiarity with traditional devices, and logistical considerations may continue to influence immobilization practices despite evolving evidence and recommendations supporting selective SMR. These findings should be interpreted in the context of the ongoing transition from routine spinal immobilization toward selective SMR. The practice of spinal immobilization has historically been considered a standard component of trauma care, particularly in prehospital settings. However, the widespread use of rigid cervical collars and spine boards was largely adopted before robust clinical evidence was available. More recent analyses have highlighted the limited high-level evidence supporting routine immobilization and have emphasized the potential complications associated with prolonged spine board use, including discomfort, pressure injuries, and respiratory compromise.⁸ The routine use of the spine board in prehospital trauma care originated in the early 1970s and was largely based on expert consensus and mechanism-of-injury criteria rather than robust clinical evidence.⁹ Over the last decade, significant changes in prehospital trauma care have shifted the paradigm from routine spinal immobilization toward selective SMR. Recent narrative and evidence syntheses have emphasized that immobilization strategies should be tailored to patient risk, minimizing unnecessary device use while preserving spinal protection when clinically indicated.³ Current recommendations limit the use of spine boards primarily to extrication purposes or to patients with clear neurological deficits or high-risk mechanisms. Importantly, no cases of spinal paralysis were observed among patients who were not immobilized, supporting the safety of more selective immobilization strategies. Previous literature has questioned the clinical benefit of routine spinal immobilization and reported that prehospital immobilization does not consistently improve neurological or functional outcomes while potentially exposing patients to complications such as respiratory impairment, increased intracranial pressure, pain, and pressure ulcers.^{10,11} Similarly, narrative reviews have highlighted the limited clinical benefit of rigid spine boards and described several adverse effects associated with their prolonged use.¹² Traditional immobilization techniques have also been criticized for potentially redistributing mechanical forces along the spine and complicating airway management, raising concerns about their overall benefit in trauma patients.¹³ Together, these findings support the ongoing transition toward selective spinal motion restriction strategies. The implementation of SMR protocols has been associated with a substantial reduction in spine board utilization without increasing the incidence of spinal cord injury among trauma patients.¹¹ Likewise, educational interventions focused on SMR have significantly reduced backboard use, with some EMS systems reporting reductions of nearly 60% following targeted training programs.¹⁴ These findings suggest that training and protocol implementation may play a key role in aligning clinical practice with current evidence-based recommendations. Despite these evolving recommendations, the optimal device for SMR remains a matter of debate.

Table 3. Perceptions and use of spinal immobilization devices.

Device	Fastest (%)	Most effective (%)
Spine board	82.6	25.6
Vacuum mattress	17.4	74.4

Biomechanical studies comparing immobilization devices have produced heterogeneous results. For example, Nolte *et al.* used motion-tracking sensors to quantify cervical spine movement during ambulance transport and reported that immobilization with a spine board combined with head blocks and straps resulted in the lowest cervical motion scores, whereas the use of a vacuum mattress was associated with greater measured motion. Interestingly, the addition of a cervical collar did not significantly improve motion restriction when head blocks and straps were already applied. These findings suggest that device performance depends not only on the type of device but also on its overall configuration and the clinical context in which it is applied. Other experimental and clinical studies have raised questions about the biomechanical performance of the spine board during transport. In a randomized crossover trial involving healthy volunteers, patients immobilized on a stretcher mattress demonstrated significantly less lateral movement compared with those secured to a spine board, suggesting that traditional immobilization devices may not always provide optimal motion restriction during ambulance transport.¹⁵ However, evidence remains heterogeneous. In a randomized clinical trial comparing a long backboard with a vacuum mattress splint in trauma patients, the long backboard was reported to be faster to apply and associated with favorable immobilization scores and higher patient comfort during prehospital management.¹⁶ These findings help explain the discrepancy observed in our study between participants' perceptions of device effectiveness and the actual clinical use of immobilization devices. Although most participants perceived the vacuum mattress as the most effective immobilization method, the spine board was perceived as faster to apply and therefore remained more commonly used in clinical practice. In time-critical prehospital environments, factors such as speed of application, ease of use, and provider familiarity may influence device selection as much as perceived device effectiveness. This may explain why traditional devices continue to be widely used despite growing evidence supporting more selective and patient-centered SMR strategies.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the survey was conducted within a single regional prehospital emergency system in central Italy, which may limit the generalizability of the results to other EMS settings with different organizational structures, training models, or operational protocols. However, Azienda USL Toscana Centro represents one of the largest prehospital emergency systems in Italy and includes both professional EMS nurses and volunteer-based advanced rescuers, reflecting a broad spectrum of providers involved in prehospital trauma care. Second, the study relied on self-reported responses regarding clinical decision-making and device use. As with most survey-based research, reported practices may not perfectly reflect real-world clinical behavior. Participants may also have been influenced by recall bias or by the tendency to provide responses perceived as consistent with recommended practice. Third, participation in the survey was voluntary, and therefore a degree of selection bias cannot be excluded. Healthcare professionals with a particular interest in trauma care or immobi-

lization practices may have been more likely to participate. Moreover, because the total number of professionals who received the survey invitation was not available, the response rate could not be calculated. Consequently, the representativeness of the respondents relative to the wider population of prehospital providers cannot be fully assessed. Furthermore, advanced rescuers represented the majority of the study sample (77.9%). Therefore, the findings may predominantly reflect the perceptions and reported practices of this professional group and should be interpreted with caution when generalizing the results to the broader population of prehospital providers. Additionally, the questionnaire did not provide an operational definition of the term “effectiveness.” Consequently, respondents may have interpreted it according to different criteria, including spinal motion restriction, patient comfort, safety, ease of application, or overall clinical usefulness.

Conclusions

This study provides insight into prehospital providers' knowledge, perceptions, and reported practices regarding the use of immobilization devices in trauma care, with particular attention to the vacuum mattress. Although the vacuum mattress was widely perceived as the most effective device for patient stabilization, it appeared to be used only rarely in clinical practice. In contrast, the spine board was perceived as faster to apply and remained commonly used in the prehospital setting. These findings highlight a discrepancy between participants' perceptions of device effectiveness and the actual clinical use of spinal immobilization devices. In time-critical prehospital environments, operational factors such as speed of application, provider familiarity, and organizational practices may strongly influence device selection. Improving training, standardizing protocols, and aligning clinical practice with evolving evidence on SMR may contribute to more consistent and evidence-informed trauma care in the prehospital setting.

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Online supplementary materials.

A questionnaire aimed at 118 nurses and advanced-level paramedics who work in the Empolese-Val d'Elsa area, with the aim of gathering information regarding their knowledge of the use of immobilisation devices on trauma patients (Italian)

Questionario rivolto agli Infermieri del 118 e soccorritori di livello avanzato che svolgono servizio nelle aree dell'empolese - val d'elsa, con lo scopo di raccogliere informazioni, in merito alle conoscenze sull' utilizzo dei presidi d'immobilizzazione sul paziente traumatico

Contributions: Lorenzo Galli, Leonardo Ceccanti and Ilario Bocchi conceived the study. Lorenzo Galli and Leonardo Ceccanti conducted data collection and statistical analysis. Leonardo Ceccanti contributed to study design refinement and manuscript drafting and revision. Flavio Gheri drafted the original manuscript. All authors critically reviewed and approved the final manuscript.

Conflict of interest: the authors declare no conflict of interest.

Ethical approval: the study was conducted in accordance with the Declaration of Helsinki and received formal authorization from the Director of the Department of Nursing and Midwifery Care of Azienda USL Toscana Centro. According to local institutional regulations, formal Ethics Committee approval was not required as no identifiable or sensitive personal data were collected.

Data availability statement: the datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of generative AI and AI-assisted technologies: no generative AI or AI-assisted technologies were used in the preparation of this manuscript.

Funding: this research received no external funding.

Received: 18 March 2026. Accepted: 17 July 2026.

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Scenario 2026; 43:682

doi:10.4081/scenario.2026.682

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