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REVIEW

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Blood transfusion training for prehospital providers: a scoping review

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Abstract

Background Blood transfusion is increasingly utilised to manage haemorrhagic shock in prehospital environments. This practice is particularly relevant in settings where delays to definitive treatment are common due to extended evacuation timelines, limited resupply, and challenging environmental conditions. Safe and effective transfusion in these contexts depends on competent, well-prepared providers. Non-physician personnel may be required to perform transfusions independently in high-stakes situations without direct physician supervision. This scoping review synthesizes current literature on blood transfusion training for prehospital providers, with a focus on instructional design, simulation modalities, knowledge retention, and outcome evaluation.

Methods We conducted a scoping review following Joanna Briggs Institute methodology and reported in accordance with the PRISMA-ScR framework. Seven databases were systematically searched through 20 February 2025. Eligible studies described transfusion training for non-physician healthcare providers in prehospital or austere environments. Data were extracted on instructional strategies, simulation modalities, and outcome measures. Outcomes were categorised using the Kirkpatrick Model, and instructional design features mapped to simulation-based education frameworks.

Results Six studies involving 475 participants were included. Participants included combat medics, paramedics, registered nurses, physician assistants, and medical students. Training was delivered across environments including simulation centres, field-based exercises, and in-theatre deployments. All studies featured face-to-face instruction and hands-on skills training. Simulation modalities included part-task trainers in four studies, high-fidelity mannequins in two, live human models in two, and real-world transfusions in one. Instructional design features such as team-based learning, repeated practice, and structured feedback were reported in most studies. Outcomes were reported across all four Kirkpatrick levels. Four studies assessed learner satisfaction and confidence (Level 1), five evaluated knowledge and procedural skill acquisition (Level 2), three assessed behavioural change in practice (Level 3), and one reported patient-level outcomes during operational missions (Level 4). None assessed long-term retention. Variability in instructional methods and limited evaluation at higher outcome levels constrained generalizability.

Conclusions Blood transfusion training for prehospital providers appears feasible and associated with short-term improvements in knowledge, skills, and confidence. However, inconsistent instructional design and limited evaluation

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of long-term or clinical outcomes indicate important gaps. Structured, simulation-informed programs aligned with operational needs may improve training consistency and effectiveness.

Keywords Blood transfusion, Prehospital care, Air ambulances, Emergency medical services, Simulation training, Medical education

Background

Hemorrhagic shock remains one of the leading causes of trauma-related combat mortality, and prompt hemorrhage control combined with restoration of intravascular volume is critical to improving survival [1–3]. Prehospital transfusion, which includes the administration of red blood cells, plasma, platelets, or whole blood before hospital arrival, has become increasingly recognized as a vital intervention in trauma care [4–7]. This practice is particularly relevant in military and austere settings, where delays to definitive treatment are common due to extended evacuation timelines, limited resupply, and challenging environmental conditions. Evidence suggests that early transfusion at or near the point of injury can significantly improve both short-term and 30-day survival, especially among combat casualties and patients treated in regions with underdeveloped prehospital systems [8, 9].

Implementing transfusions in remote and resource-limited environments poses significant challenges, including the need to preserve product integrity through cold chain maintenance, ensure supply chain continuity, and make timely decisions under operational stress [10–12]. Despite these constraints, military *Blood Far Forward* programs have shown that prehospital transfusion is not only feasible but potentially life-saving when delivered by small, mobile teams trained to operate autonomously [13–15]. In many cases, these teams are staffed by non-physician providers such as medical technicians, paramedics, registered nurses, and physician assistants, all of whom may be required to perform transfusions independently in high-stakes situations without direct physician supervision [15–17].

As the operational use of prehospital transfusion expands, questions remain about how best to prepare providers for independent practice in austere settings. Although guidelines such as the Joint Trauma System Clinical Practice Guideline for Prehospital Blood Transfusion emphasize structured, scenario-based instruction [18], few studies describe the delivery of training, instructional strategies used, or methods of outcome evaluation. The absence of standardized approaches limits the identification of best practices and may hinder interoperability across allied military medical systems.

Simulation-based education is well established in the training of healthcare professionals for high-acuity, low-occurrence (HALO) procedures such as transfusion in prehospital and austere settings [19–21]. Instructional design features including repetitive practice, targeted feedback, mastery learning, and scenario variability have been linked to improved knowledge acquisition, technical skill, and long-term retention [22, 23]. Within transfusion medicine specifically, simulation has been used to reinforce safety protocols, enhance team-based decision-making, and prepare providers for rare but critical interventions [24, 25].

Nonetheless, transfusion training programs often emphasize short-term outcomes like confidence and knowledge while overlooking whether learning translates into changes in behaviour or patient outcomes [26, 27]. At present, prehospital transfusion remains largely limited to specialized military units such as Special Operations Forces (SOF) or forward aeromedical evacuation teams [15–17]. Expanding this capability to broader segments of the armed forces is essential to improve trauma system responsiveness and operational readiness. To support this expansion, training must be accessible, evidence-based, and tailored to operational realities, accounting for factors such as provider turnover, variable clinical exposure, and logistical constraints.

This scoping review aims to synthesize current literature on blood transfusion training for prehospital providers, with a focus on instructional design, simulation modalities, and outcome evaluation. The findings are intended to inform the development of standardized, simulation-based curricula that support safe, effective, and scalable transfusion capability across civilian and military prehospital care organizations.

Methods

Study design

This scoping review was conducted using the methodological guidance from the Joanna Briggs Institute (JBI) for scoping reviews [28]. The protocol was prospectively registered on the Open Science Framework (OSF) (https://doi.org/10.17605/OSF.IO/HJYBP). Reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (Appendix 1) [29]. The research team included individuals with expertise in trauma, prehospital care, critical care transport, medical education, methodology, and health information science. As this study involved a review of publicly available literature, it did not require ethics approval from an Internal Review Board.

PICOS framework

This review was guided by the Population, Intervention, Comparator, Outcomes, and Setting (PICOS) framework [30]. The population of interest included non-physician providers and trainees, such as medical technicians, paramedics, registered nurses and physician assistants. Studies focusing exclusively on physicians were excluded. However, studies including mixed cohorts were eligible if they included non-physician providers and reported results applicable to this group. The intervention of interest was transfusion training delivered in prehospital contexts, with an emphasis on knowledge acquisition, skill development, long-term skill retention and applicability in resource-limited or operational environments. Comparative designs, including pre-post studies, randomized controlled trials, and non-randomized studies, were eligible.

Outcomes were mapped using the Kirkpatrick Model [31], with Level 1 (reaction) referring to satisfaction with training, Level 2 (learning) referring to changes in knowledge and skills, Level 3 (behaviour) assessing application in practice, and Level 4 (results) evaluating patient or system-level outcomes. Instructional design features were coded using simulation-based education frameworks, including distributed practice, cognitive interactivity, feedback, group learning, mastery-based progression, and scenario variability [22, 23]. Skill-related outcomes were classified into time (duration to completion), process (accuracy, efficiency), and product (final outcome quality or clinical effect). This framework ensured consistency in mapping training content, delivery methods, and educational outcomes relevant to prehospital transfusion.

Identifying relevant information sources

A comprehensive search strategy was developed in collaboration with an information specialist, using standard practices for peer-reviewed electronic search design [32]. The following databases were searched from inception to February 20, 2025: MEDLINE, Embase, CINAHL, Scopus, Web of Science, CENTRAL, and PsycINFO. Only empirical studies published in English or French were eligible. Grey literature was explored through targeted searches of conference proceedings, relevant agency websites, and by reviewing the reference lists of included studies. The search strategy is provided in Appendix 2.

Eligibility criteria

Inclusion criteria were broad to capture a range of empirical study designs evaluating or describing transfusion training strategies for non-physician healthcare providers in prehospital settings. Studies needed to describe an educational intervention or training approach applicable to clinical or simulated environments. No restrictions were placed on date or participant age. Studies were excluded if they were commentaries, editorials, letters, book chapters, or conference abstracts without accompanying data.

Article selection process

An iterative, three-stage screening process was conducted using Covidence (version 2.0, Veritas Health Innovation, Melbourne, Australia). Two independent reviewers screened titles and abstracts in duplicate using a pilot-tested screening tool based on the eligibility criteria. Discrepancies were resolved through discussion or by a third reviewer. Full texts were then reviewed in duplicate, and reasons for exclusion were documented. The final set of included studies was reviewed by the full investigator team to ensure completeness. A PRISMA 2020 flow diagram summarizing the study selection process is provided in Fig. 1 [33].

Data charting process

Data from included studies were charted using a structured template developed a priori, capturing study characteristics, participant details, instructional design features, setting, simulation modality, and Kirkpatrick-level outcomes. The charting process was completed by reviewer pairs independently, with consensus reached through discussion. Extracted data were synthesized descriptively and presented as narrative summaries aligned with scoping review guidance [28]. No formal critical appraisal of included studies was performed, consistent with the methodological guidance for scoping reviews [34, 35].

Results

A total of 4754 records were identified through database searching. Following title and abstract screening, 48 full-text articles were assessed for eligibility. Of these, six studies met the inclusion criteria and were included in the final analysis [26, 27, 36–39]. The selection process is presented in Fig. 1 using the PRISMA-ScR flow diagram [33].

The six included studies varied in design, population, and training modality. Study designs included prospective observational studies ($n = 2$), non-randomised experimental studies with pre-post assessments ($n = 3$), and a case series ($n = 1$). Sample sizes ranged from 8 to 165 participants, yielding a combined total of 475 individuals trained in prehospital transfusion practices. Most participants were military-affiliated ($n = 467$, 98%), while one study involved civilian personnel preparing for deployment in a conflict setting ($n = 8$, 2%).

Participants included combat medics, special operations medical technicians, registered nurses, physician assistants, and medical students. Training settings included in-theater deployments, simulation centres, and

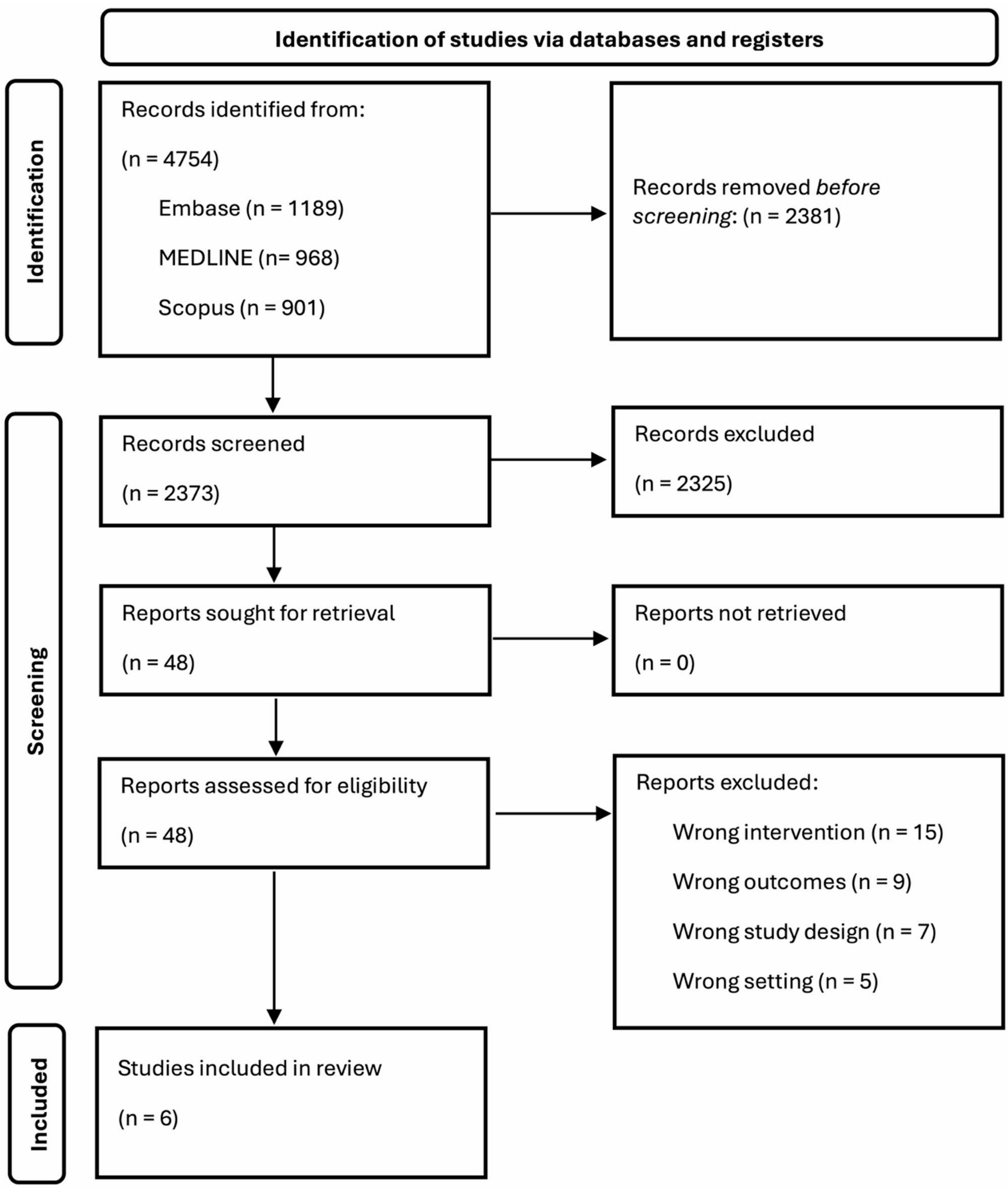

Fig. 1 PRISMA Flow Diagram

field-based exercises. Five studies (83%) were conducted in the United States; others were affiliated with training programs intended for multinational or deployed applications, including Ukraine and Afghanistan.

Instructional methods included face-to-face lectures, team-based simulation exercises, part-task trainer sessions, autologous transfusion procedures, and field-based practical stations. Simulation modalities varied:

Table 1 Characteristics of included studies

Study	Country	Design	Sample Size	Setting	Participants	Training Modality	Simulation Modality	Kirkpatrick Levels Assessed
Benavides (2017)	USA, UK	Performance improvement (pre-post)	44	Military	SOF medics, combat medics, registered nurses, physicians (mixed cohort)	In-theater practical training with didactics and drills	Live human models, part task trainers	1, 2, 3
Brown (2024)	USA (training), Ukraine (application)	Pre-post interventional study	8	Civilian	Ukrainian physicians and medics (mixed cohort)	Hands-on simulation with mock equipment	Part task trainers, high-fidelity mannequins	1, 2, 3
Cole (2024)	USA	Non-randomised experimental (pre-post)	157	Military	Medical students	Simulation-based field exercise	High-fidelity mannequins, field simulation	1, 2
Matthews (2024)	USA	Non-randomised experimental (pre-post)	165	Military	Medical students	Online modules + in-person IV skill station	Part task trainers (IV arms)	1, 2, 3
Malsby (2013)	Afghanistan (USA military)	Case series	15	Military	Flight medics and critical care nurses	Real-world transfusions with SOP oversight	None (real transfusion on patients)	3, 4
Schauer (2023)	USA	Prospective observational study	86	Military	Combat medics and SOF medics	Autologous transfusion in simulated field setting	Live human models (autologous)	2, 3

Note: Studies were eligible for inclusion if they involved non-physician providers (e.g., paramedics, registered nurses, physician assistants) and reported outcomes relevant to this group. Studies with mixed cohorts that included physicians were retained only if the training intervention and outcome data were applicable to non-physician participants. Participant roles and simulation modalities are reported as described in the original studies

four studies (67%) used part-task trainers, two (33%) used high-fidelity mannequins, two (33%) employed live human models, and one (17%) included autologous blood donation and transfusion. One study (17%) reported on live transfusions administered during operational medical evacuation (MEDEVAC) missions. A detailed summary of study characteristics is provided in Table 1.

Training was delivered in diverse prehospital environments, including simulation centers, field exercises, and in-theater operational settings. All studies ($n=6$, 100%) included face-to-face instruction, with training methods that incorporated task-based skill stations, simulation, autologous transfusion drills, and team-based rehearsal. One study included real-world blood transfusions during MEDEVAC operations. Online components were used in one study ($n=1$, 17%).

Simulation modalities varied. Part-task trainers were used in $n=4$ (67%) studies, high-fidelity mannequins in $n=2$ (33%), and live human models in $n=2$ (33%). One study ($n=1$, 17%) involved autologous blood collection and transfusion with live participants, and one study ($n=1$, 17%) relied on actual clinical transfusions rather than simulated procedures.

Instructional design features were inconsistently reported but frequently present. All studies ($n=6$, 100%) involved expert instructors. Group-based learning and repetitive practice were each included in $n=5$ (83%) studies. Feedback mechanisms were also described in $n=5$ (83%). Curricular integration was explicitly reported in $n=4$ (67%), and mastery learning approaches were used in $n=3$ (50%). Distributed practice over multiple sessions was reported in $n=2$ (33%), and multiple instructional strategies were combined in $n=4$ (67%).

All six studies ($n=6$, 100%) reported positive training outcomes. Kirkpatrick Level 1 outcomes—such as participant satisfaction and confidence, were assessed in $n=4$ (67%) studies. Level 2 outcomes, related to knowledge and skill acquisition, were evaluated in $n=5$ (83%). In all studies with pre- and post-training assessments ($n=5$, 83%), participants showed measurable improvements in knowledge, procedural accuracy, and self-reported confidence.

Three studies ($n=3$, 50%) reported Level 3 outcomes, reflecting behavioural change during simulations or in operational contexts. Only one study ($n=1$, 17%) reported Level 4 outcomes, documenting transfusion safety and patient survival during real-world missions. None of the included studies evaluated long-term retention of transfusion skills or delayed performance outcomes.

The included studies suggest that transfusion training in prehospital contexts can improve provider knowledge, skills, and confidence. However, the evidence remains limited by variability in training methods, lack of standardization, and inconsistent outcome reporting. Evaluation at higher Kirkpatrick levels was infrequent, and no study assessed long-term retention. These gaps highlight the need for standardized training frameworks supported by robust assessment strategies, particularly for settings where providers must perform blood transfusions under operational constraints.

Discussion

This scoping review synthesizes evidence on how blood transfusion training is delivered to prehospital providers and finds it is feasible, commonly simulation-based, and associated with short-term improvements in knowledge acquisition, procedural skill, and learner confidence [26, 27, 36–39]. The majority of prehospital transfusion training programs were conducted in military or austere settings and frequently included face-to-face instruction, simulation activities, and team-based learning. However, several key instructional design features, such as scenario variation, structured feedback, and distributed practice, were not consistently reported across studies.

These findings are consistent with broader simulation-based education literature, which highlights the importance of mastery learning, deliberate practice, and expert feedback in promoting the development and retention of complex clinical skills [40–42]. Simulation has been shown to improve technical performance, clinical decision-making, team communication, and adherence to transfusion protocols in both hospital-based and austere environments [24, 25]. Despite this, Only a minority of the included studies incorporated high-fidelity simulation modalities, such as mannequin-based scenarios or live tissue training, and just one evaluated transfusion practices in a real-world clinical context [37]. The limited use of simulation methodologies that have demonstrated educational benefit may hinder opportunities to translate training into clinical performance and patient outcomes [42–44].

The outcomes reported in the reviewed studies were primarily at Kirkpatrick Levels 1 and 2, including participant satisfaction, confidence, knowledge improvement, and procedural accuracy [31, 43]. Three studies assessed behavior change in a simulated or operational setting (Level 3), and only one reported outcomes at the patient level (Level 4), such as transfusion safety and clinical effectiveness. None of the studies included assessments of long-term skill retention, despite evidence that sustained performance often requires repeated exposure and refresher training over time [45, 46].

Compared to standardized training programs such as Advanced Trauma Life Support (ATLS) and Tactical Combat Casualty Care (TCCC), transfusion training remains less standardized, infrequently evaluated at higher levels of educational effectiveness, and rarely embedded within formal certification or sustainment programs [47, 48]. This lack of standardization is particularly important as prehospital transfusion capabilities are extended from specialized teams to broader healthcare personnel, including conventional military forces and civilian prehospital care organizations [15–17]. As transfusion becomes more widely practiced in the prehospital setting, training models must be scaled appropriately to ensure readiness and patient safety.

Although the included studies are predominantly from military settings focused on penetrating trauma, civilian prehospital systems typically manage blunt trauma and have different scopes of practice. These contextual differences have implications for training priorities, decision-making frameworks, and resource availability. Adapting military-based training content to civilian providers may require modification to align with their clinical exposure and regulatory scope.

Non-physician providers represent a heterogeneous group, ranging from military medics with limited formal training to registered nurses and paramedics with advanced degrees. This variability in foundational training and clinical exposure affects the generalizability and design of transfusion training programs.

Beyond procedural competency, effective prehospital transfusion requires accurate identification of patients likely to benefit. Decision-making in austere settings is complex, and validated clinical triggers remain limited. Training programs should incorporate education on physiological markers, vital sign trends, and contextual risk factors to guide transfusion decisions. Ongoing research into point-of-care diagnostics may support earlier recognition of hemorrhagic shock and should be integrated into future curricula.

Although training should include the recognition and management of transfusion reactions, differentiating these from symptoms of hemorrhagic shock is difficult in the prehospital setting. Severe reactions, such as ABO incompatibility, are rare and often unsurvivable without immediate hospital-level care. As such, emphasis should be placed on protocol adherence and product compatibility rather than on-field diagnosis of reactions.

Based on the findings of this review and established educational frameworks, a comprehensive transfusion training program should include both theoretical and practical components. Didactic modules should address foundational topics such as transfusion physiology, compatibility, storage and cold chain logistics (i.e., maintaining appropriate temperature control during blood transport and storage), and the recognition and management of transfusion reactions [10, 11]. Procedural instruction should cover IV and IO access, transfusion technique, field documentation, and decision-making under operational constraints [49]. Simulation-based learning should incorporate both part-task training and full scenario exercises that simulate environmental stressors, limited resources, and time-sensitive care priorities [20, 21]. Instruction should follow the principles of mastery learning and include distributed practice, feedback, and scenario variation to ensure learners achieve competence prior to deployment [22]. Evaluation strategies should include validated checklists and observational tools, and where feasible, extend to patient or system-level outcomes [31, 43]. Integration of transfusion education into professional development frameworks and alignment with clinical scope of practice would support institutional adoption and sustainment. Embedding simulation into recurring training cycles may also support long-term skill retention and workforce sustainability.

The clinical implications of these findings are substantial. Simulation-informed transfusion education has the potential to reduce preventable mortality from hemorrhage, improve adherence to clinical protocols, and enhance trauma care delivery in environments where immediate access to definitive treatment may not be possible [1–3]. Empowering non-physician providers to deliver prehospital transfusions competently and independently aligns with the principles of remote damage control resuscitation and reflects evolving operational needs [11, 12]. Standardized education, supported by simulation and outcome-based evaluation, may also reduce variation in practice and promote consistency across units and care settings.

This review was conducted in accordance with established scoping review methodology [28], using a peer-reviewed search strategy [32] and a multidisciplinary team with expertise in trauma care, prehospital care, critical care transport and medical education. While the review was comprehensive, several limitations should be considered. The number of included studies was small, and most used pre-post or descriptive study designs with limited generalizability. The absence of formal quality appraisal, consistent with scoping review standards [34], means that risk of bias could not be assessed. Additionally, most studies were conducted in the United States, which may limit the applicability of findings to other national or organizational contexts.

Future research should examine how transfusion training impacts provider behaviour and patient outcomes over time. Longitudinal studies using frameworks such as the Kirkpatrick Model and the behaviour change wheel could help determine which educational strategies produce the most durable and clinically relevant results [31, 50]. Comparative evaluations of simulation modalities, instructional design, and implementation models may also help optimize training development. Finally, incorporating transfusion education into broader operational readiness and sustainment programs may provide a scalable and system-level approach to improving trauma care delivery in austere environments.

Conclusion

This scoping review identified a limited but growing body of evidence on blood transfusion training for prehospital providers, primarily in military and austere settings. The included studies suggest that this training is feasible and associated with short-term improvements in knowledge, procedural skills, and learner confidence. However, variability in instructional design, limited use of simulation-based practices, and a lack of evaluation at higher outcome levels indicate important gaps. Structured curricula based on established educational frameworks and aligned with operational requirements may support more consistent and effective training.

Abbreviations

ATLS	Advanced Trauma Life Support
BEME	Best Evidence Medical Education
CAF	Canadian Armed Forces
CINAHL	Cumulative Index to Nursing and Allied Health Literature
DLN	Distributed Learning Network
EMS	Emergency Medical Services
HALO	High Acuity, Low Occurence
HEMS	Helicopter Emergency Medical Services
IV	Intravenous
JBI	Joanna Briggs Institute
MEDEVAC	Medical Evacuation
OSF	Open Science Framework
PA	Physician Assistant
PICOS	Population, Intervention, Comparator, Outcome, Setting
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews
PRESS	Peer Review of Electronic Search Strategies
RN	Registered Nurse
SBME	Simulation-Based Medical Education
SOP	Standard Operating Procedure
SOF	Special Operations Forces
TCCC	Tactical Combat Casualty Care
USA	United States of America
UK	United Kingdom

Supplementary Information

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Supplementary Material 1

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Author contributions

All the authors contributed to the conception and design of the study. PMD, KS and JC collected and analysed the data. PMD prepared the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Human ethics and consent to participate
Not applicable. This study did not involve human participants and did not require ethics approval.

Ethics approval
Not applicable. No ethics approval was required for this scoping review as it did not involve primary data collection or human participants.

Consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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