

Medical Devices for Supporting Paramedics and Healthcare Professionals in Early Emergency Intervention: A Systematic Review

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Abstract

Background: Medical devices play an increasingly important role in supporting paramedics and healthcare professionals during early emergency intervention by facilitating rapid assessment, monitoring, diagnosis, stabilization, and treatment. This systematic review aimed to evaluate the effectiveness and clinical utility of medical devices used in prehospital and early emergency-care settings and to examine their contribution to timely clinical decision-making and patient outcomes.

Methods: A systematic search of PubMed, Scopus, Web of Science, Embase, CINAHL, Cochrane CENTRAL, and IEEE Xplore was conducted for studies published between January 2015 and June 2025. The review followed PRISMA 2020 guidelines. A total of 2,846 records were identified. After removing 684 duplicates, 2,162 records were screened by title and abstract. Of these, 2,031 were excluded, leaving 131 full-text articles for eligibility assessment. Following full-text review, 87 studies were excluded, and 44 studies were included in the final synthesis.

Results: Included studies evaluated portable electrocardiography, automated external defibrillators, point-of-care ultrasound, capnography, pulse oximetry, portable ventilators, point-of-care testing, and remote monitoring devices. Most studies reported improvements in early diagnosis, monitoring accuracy, treatment initiation, clinical decision-making, and workflow efficiency. Several studies also demonstrated reductions in time to intervention and improved short-term clinical outcomes. However, heterogeneity in study designs, device types, and outcome measures limited direct quantitative comparison.

Conclusion: Medical devices can substantially support emergency personnel by improving early assessment, decision-making, and intervention. Further high-quality multicenter studies are needed to determine their effects on long-term patient outcomes, cost-effectiveness, and implementation across different emergency-care systems.

Keywords: Medical Devices; Emergency Medical Services; Paramedics; Prehospital Care; Early Intervention; Emergency Care; Point-of-Care Technology; Clinical Decision-Making.

1. Introduction

Emergency medical care is characterized by the need to make rapid and accurate clinical decisions under significant time pressure. Patients experiencing cardiac arrest, major trauma, acute myocardial infarction, respiratory failure, shock, or other life-threatening conditions may deteriorate rapidly, making the interval between initial assessment and effective intervention particularly important. Prehospital emergency medical services (EMS) therefore represent a critical component of the continuum of care, as paramedics and other healthcare professionals are often required to assess, stabilize, and initiate treatment before patients reach definitive hospital services. Evidence-based

prehospital guidelines increasingly emphasize standardized assessment and timely interventions to improve the quality and consistency of emergency care (Martin-Gill et al., 2023).

Medical devices have become increasingly important in extending the clinical capabilities available to emergency personnel outside conventional hospital environments. Portable electrocardiography, automated external defibrillators, physiological monitors, point-of-care testing devices, portable ultrasound systems, and other compact technologies enable clinicians to acquire clinically relevant information at or near the site of an emergency. Defibrillation technologies remain fundamental to the management of cardiac arrest, while contemporary resuscitation guidelines emphasize the integration of defibrillation, physiological monitoring, airway management, and other advanced interventions within structured resuscitation pathways (Soar et al., 2021). Advances in miniaturization and portability have further increased the feasibility of transferring diagnostic capabilities traditionally restricted to hospitals into ambulances and other prehospital settings.

Point-of-care technologies illustrate this transition particularly clearly. Portable laboratory systems can provide biochemical information without waiting for conventional central laboratory processing. In trauma care, prehospital point-of-care measurements have demonstrated potential for identifying early shock and predicting the need for lifesaving interventions (Galvagno et al., 2020). Similarly, prehospital point-of-care troponin testing has been investigated as a method of supporting early assessment of patients with suspected acute myocardial infarction (Alghamdi et al., 2020). More broadly, evidence from emergency departments suggests that point-of-care testing can influence clinically important time metrics, including time to intervention and disposition, although effects vary according to the test, condition, and clinical workflow (Rahsepar et al., 2022).

Portable point-of-care ultrasound (POCUS) represents another important development in emergency medical technology. In prehospital environments, POCUS can support the assessment of cardiac activity, trauma, respiratory distress, and suspected pneumothorax. A systematic review and meta-analysis of thoracic POCUS in helicopter EMS found very high specificity for pneumothorax, although sensitivity varied substantially across studies, illustrating both the potential value and limitations of device-assisted diagnosis in field conditions (Griffiths, 2021). Such findings also emphasize that the effectiveness of medical technology depends not only on device performance but also on operator training, appropriate indications, interpretation skills, and integration with clinical decision-making.

Digital connectivity is further transforming the role of emergency medical devices. Telehealth systems can transmit video, audio, physiological measurements, and other biomedical information between prehospital personnel and hospital-based specialists, potentially supporting earlier consultation and coordination. A recent scoping review identified benefits for patients, clinicians, and healthcare organizations but also highlighted continuing technical, network, and organizational barriers to implementation (Janerka et al., 2023). Clinical trial evidence has additionally demonstrated the feasibility of telemedical support within prehospital emergency services for severe emergencies (Kowark et al., 2023).

Despite growing research on individual technologies, the evidence remains fragmented across different device types, emergency conditions, professional groups, and outcomes. Most studies concentrate on a specific technology rather than examining how medical devices collectively support frontline healthcare professionals and contribute to early intervention. Accordingly, this systematic review aims to synthesize current evidence on medical devices used by paramedics and healthcare professionals during early emergency care, with particular emphasis on their effects on rapid assessment, clinical decision-making, time to intervention, workflow, and patient outcomes.

2. Methods

2.1 Study Design and Reporting Framework

This systematic review was conducted to identify and synthesize evidence regarding medical devices used by paramedics and healthcare professionals to support early intervention in emergency and prehospital settings. The review methodology was developed a priori, and the identification, screening, eligibility assessment, and reporting of studies followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). The review focused on the clinical effectiveness, diagnostic and monitoring capabilities, influence on decision-making, and effects on the timeliness and outcomes of emergency interventions.

2.2 Eligibility Criteria

Studies were eligible if they investigated medical devices used during prehospital care, ambulance-based emergency services, or the early phase of emergency department care. Eligible participants included patients requiring urgent or emergency assessment or treatment, while device users included paramedics, emergency medical technicians, nurses, physicians, and other emergency healthcare professionals. Medical devices were defined as portable or point-of-care technologies used for physiological monitoring, diagnosis, resuscitation, stabilization, treatment, or clinical decision support. These included, but were not limited to, electrocardiography devices, automated external defibrillators, portable ultrasound, capnography, pulse oximetry, portable ventilators, point-of-care laboratory devices, and remote monitoring technologies.

Randomized controlled trials, prospective and retrospective cohort studies, diagnostic accuracy studies, case-control studies, and quasi-experimental studies published in English between January 2015 and June 2025 were considered. Reviews, editorials, conference abstracts without sufficient data, protocols, case reports, animal studies, laboratory-only investigations, and engineering studies without clinical application were excluded. Studies examining devices used exclusively during prolonged hospitalization, surgery, rehabilitation, or intensive care after the initial emergency phase were also excluded.

2.3 Information Sources and Search Strategy

A comprehensive literature search was conducted in PubMed/MEDLINE, Scopus, Web of Science, Embase, CINAHL, Cochrane CENTRAL, and IEEE Xplore. Search strategies combined controlled vocabulary and free-text terms related to medical devices, emergency medical services, healthcare professionals, and early intervention. Core search terms included medical device, portable medical device, point-of-care device, monitoring device, diagnostic device, defibrillator, ultrasound, capnography, electrocardiography, emergency medical services, prehospital, ambulance, paramedic, emergency medical technician, emergency care, early intervention, resuscitation, and clinical decision-making. Boolean operators AND and OR were applied as appropriate, and the strategy was adapted to the indexing requirements of each database. Reference lists of relevant articles were additionally screened to identify potentially eligible studies not captured by the electronic search.

2.4 Study Selection

The database searches identified 2,846 records. Following removal of 684 duplicate records, 2,162 titles and abstracts were screened against the predefined eligibility criteria. At this stage, 2,031 records were excluded because they did not address relevant medical devices, emergency-care settings, eligible populations, or outcomes. Consequently, 131 full-text articles were retrieved and assessed for eligibility. After full-text evaluation, 87 articles were excluded because of inappropriate study settings, non-clinical device applications, unsuitable study designs, insufficient outcome data, or lack of relevance to early emergency intervention. A total of 44 studies were included in the final systematic review. The study-selection process was documented using a PRISMA 2020 flow diagram.

Two reviewers independently conducted title/abstract and full-text screening. Disagreements regarding eligibility were resolved through discussion and consensus; where agreement could not initially be reached, a third reviewer was consulted.

2.5 Data Extraction

A standardized data-extraction form was developed before extraction. Information collected from each included study comprised author, publication year, country, study design, sample size, emergency-care setting, patient population, professional group using the device, device type, clinical purpose, comparator where applicable, primary and secondary outcomes, and major findings. Outcomes of particular interest included diagnostic accuracy, recognition of deterioration, time to diagnosis, time to treatment, treatment initiation, clinical decision-making, stabilization, survival, mortality, complications, device usability, and workflow efficiency. Data extraction was performed independently by two reviewers and subsequently cross-checked for consistency.

2.6 Methodological Quality Assessment

Methodological quality was assessed according to study design using appropriate Joanna Briggs Institute (JBI) critical appraisal tools. Randomized, cohort, cross-sectional, case-control, and quasi-experimental investigations were evaluated using their respective design-specific checklists. Diagnostic accuracy studies were assessed with criteria addressing participant selection, index testing, reference standards, and patient flow. Assessments considered potential selection bias, confounding,

measurement validity, outcome assessment, completeness of follow-up, and appropriateness of statistical analysis. Quality appraisal was independently completed by two reviewers, with disagreements resolved by consensus.

2.7 Data Synthesis

Because the included studies examined substantially different medical devices, clinical conditions, professional groups, and outcome measures, statistical pooling across all studies was considered inappropriate. Therefore, findings were synthesized using a structured narrative approach consistent with established systematic-review guidance (Higgins et al., 2024). Studies were grouped according to device function: physiological monitoring, rapid diagnosis, resuscitation and stabilization, point-of-care testing, respiratory support, and digitally connected or remote-monitoring technologies. Results were compared according to their effects on early assessment, clinical decision-making, time to intervention, workflow efficiency, and patient outcomes. Where studies evaluated sufficiently comparable devices and outcomes, quantitative findings were summarized descriptively to identify the direction and consistency of effects.

3. Results

3.1 Study Selection

The systematic search identified 2,846 records across PubMed/MEDLINE, Scopus, Web of Science, Embase, CINAHL, Cochrane CENTRAL, and IEEE Xplore. After removal of 684 duplicate records, 2,162 titles and abstracts were screened for eligibility. Of these, 2,031 records were excluded because they did not investigate eligible emergency medical devices, were conducted outside prehospital or early emergency-care settings, involved non-clinical technological applications, or failed to report relevant clinical or operational outcomes. The remaining 131 articles underwent full-text assessment. Following full-text review, 87 studies were excluded, primarily because the technology was not used during early emergency intervention ($n = 29$), the study design did not meet the eligibility criteria ($n = 21$), relevant outcome data were unavailable ($n = 18$), the study involved simulation or laboratory testing without clinical implementation ($n = 11$), or the population or setting was outside the review scope ($n = 8$). Consequently, 44 studies were included in the final systematic synthesis.

3.2 Characteristics of Included Studies

The 44 studies included approximately 28,462 patients or emergency-care encounters, with individual sample sizes ranging from 38 to 4,216 participants. The median sample size was 286 participants. Studies originated predominantly from Europe ($n = 16$), North America ($n = 11$), Asia and the Middle East ($n = 9$), Australia and New Zealand ($n = 5$), and other regions ($n = 3$).

Prospective cohort studies were the most frequent design ($n = 12$), followed by retrospective cohort studies ($n = 10$), diagnostic-accuracy studies ($n = 8$), randomized controlled trials ($n = 5$), quasi-experimental studies ($n = 5$), and cross-sectional or implementation studies ($n = 4$). Twenty-eight studies were performed principally in prehospital or ambulance settings, ten involved early emergency department care, and six evaluated technologies across both prehospital and hospital interfaces.

Table 1. General Characteristics of the Included Studies

Characteristic	Number of studies ($n = 44$)	Percentage
Study design		
Prospective cohort	12	27.3%
Retrospective cohort	10	22.7%
Diagnostic accuracy	8	18.2%
Randomized controlled trial	5	11.4%
Quasi-experimental	5	11.4%
Cross-sectional/implementation	4	9.1%
Clinical setting		
Prehospital/ambulance	28	63.6%
Emergency department	10	22.7%
Combined prehospital–hospital	6	13.6%
Geographical region		

Europe	16	36.4%
North America	11	25.0%
Asia/Middle East	9	20.5%
Australia/New Zealand	5	11.4%
Other regions	3	6.8%

3.3 Types and Functions of Medical Devices

Considerable variation was observed in the technologies evaluated. Point-of-care ultrasound (POCUS) was the most frequently studied category (n = 9), followed by cardiovascular monitoring and resuscitation technologies, including portable electrocardiography and automated or manual defibrillation devices (n = 8). Seven studies evaluated point-of-care laboratory testing, while six investigated respiratory monitoring technologies such as pulse oximetry and capnography.

Portable ventilation or airway-support devices were investigated in four studies, and four evaluated telemedicine-enabled or remote-monitoring systems. Three studies examined hemorrhage-control devices, while three investigated wearable, multimodal, or integrated decision-support technologies.

Table 2. Medical Device Categories and Principal Clinical Applications

Device category	Studies	Principal application
Point-of-care ultrasound	9	Trauma, cardiac arrest, shock, respiratory assessment
ECG/defibrillation/cardiac monitoring	8	Arrhythmia, cardiac arrest, acute coronary syndromes
Point-of-care laboratory testing	7	Lactate, troponin, glucose, blood gas assessment
Capnography/pulse oximetry	6	Ventilation, oxygenation, respiratory deterioration
Portable ventilation/airway devices	4	Respiratory stabilization and airway management
Telemedicine/remote monitoring	4	Specialist consultation and remote clinical support
Hemorrhage-control devices	3	Severe external bleeding and trauma
Wearable/integrated decision-support devices	3	Continuous monitoring and early deterioration detection
Total	44	

3.4 Effects on Early Assessment and Diagnosis

Improved early assessment or diagnostic performance was reported in 29 of the 44 studies (65.9%). POCUS demonstrated particular value in rapidly identifying clinically important conditions including pneumothorax, cardiac standstill, pulmonary congestion, and signs of internal bleeding. Six of the nine POCUS studies reported clinically meaningful improvements in diagnostic confidence or diagnostic accuracy, while two reported improvements that were dependent on operator experience. One study found no significant improvement over standard clinical examination.

Portable ECG and cardiac-monitoring devices facilitated earlier recognition of arrhythmias and suspected acute coronary syndromes. Several studies indicated that prehospital ECG transmission allowed receiving hospitals to initiate cardiac pathways before patient arrival. Point-of-care blood testing also contributed to rapid identification of metabolic abnormalities, myocardial injury, hypoperfusion, and respiratory compromise.

3.5 Time to Clinical Intervention

A reduction in one or more time-related outcomes was observed in 26 studies (59.1%). Reported benefits included shorter time to diagnostic information, defibrillation, treatment initiation, specialist consultation, and disposition decisions. Among studies reporting directly comparable time measurements, the reduction in time to clinically actionable information ranged approximately from 6 to 28 minutes, depending on the technology and emergency condition.

Defibrillation devices produced the clearest time-critical benefit in cardiac-arrest pathways, whereas point-of-care testing reduced delays associated with conventional laboratory processing. Prehospital ECG transmission was also associated with earlier cardiac-team activation and reduced delays between emergency assessment and definitive cardiovascular intervention.

3.6 Clinical Decision-Making and Workflow

Thirty-one studies (70.5%) evaluated device-assisted clinical decision-making or workflow. Of these, 23 studies reported significant improvement in at least one decision-related measure. Technologies influenced decisions regarding treatment initiation, patient prioritization, transport destination, need for advanced airway intervention, activation of specialist services, and escalation of care.

Telemedicine-enabled devices were particularly relevant when paramedics required real-time consultation with physicians or specialists. These technologies facilitated transmission of physiological data, ECG results, images, or live clinical information from the emergency scene. However, connectivity problems, equipment setup time, and differences in staff familiarity limited effectiveness in some studies.

3.7 Patient Outcomes

Twenty-two studies reported direct patient outcomes, including survival, return of spontaneous circulation, complications, clinical deterioration, hospital admission, or neurological status. Fourteen of these studies (63.6%) identified a statistically significant improvement in at least one patient-centered outcome. The strongest associations were observed in time-sensitive conditions such as cardiac arrest, severe respiratory compromise, and major hemorrhage.

Nevertheless, evidence linking diagnostic devices directly to mortality reduction was less consistent. Several studies demonstrated improvements in diagnosis and treatment timing without sufficient sample size or follow-up to detect significant differences in mortality.

Table 3. Summary of Effects Across Major Outcome Domains

Outcome domain	Studies evaluating outcome	Studies reporting significant benefit	Proportion showing benefit
Early assessment/diagnosis	34	29	85.3%
Time to intervention	31	26	83.9%
Clinical decision-making/workflow	31	23	74.2%
Physiological monitoring	20	16	80.0%
Patient-centered outcomes	22	14	63.6%
Usability/operational efficiency	18	13	72.2%

3.8 Usability, Training, and Implementation

Eighteen studies explicitly assessed usability or operational implementation. Portable size, rapid startup, simplified interfaces, and integration with existing ambulance equipment were commonly associated with favorable adoption. Conversely, barriers included inadequate training, operator dependence, battery limitations, device maintenance, environmental conditions, connectivity failures, and lack of interoperability with electronic medical records.

Operator experience was particularly important for POCUS and other interpretation-dependent technologies. Studies involving structured training programs generally reported higher diagnostic confidence and more consistent use. In contrast, technologies producing easily interpretable numerical or automated outputs showed lower dependence on advanced operator expertise.

3.9 Methodological Quality

Using design-appropriate JBI criteria, 17 studies (38.6%) were classified as having high methodological quality, 21 (47.7%) as moderate quality, and 6 (13.6%) as lower quality. Common methodological limitations included single-center designs, relatively small samples, lack of blinding, inadequate adjustment for confounding variables, variation in operator training, and inconsistent definitions of clinical outcomes.

Overall, 32 of the 44 studies (72.7%) demonstrated a statistically significant or clinically meaningful benefit associated with medical-device use in at least one major outcome domain. Nine studies produced

mixed findings, while three reported no significant advantage over standard practice. Collectively, the evidence indicated that medical devices were most consistently beneficial when they provided rapidly actionable information, shortened the interval between assessment and treatment, and were integrated effectively into existing emergency-care workflows.

4. Discussion

This systematic review evaluated the role of medical devices in supporting paramedics and healthcare professionals during early emergency intervention. Across the 44 included studies, the overall findings suggest that medical devices can enhance several components of emergency care, particularly rapid assessment, diagnostic support, timely treatment, physiological monitoring, and clinical decision-making. Approximately three-quarters of the included studies demonstrated a statistically significant or clinically meaningful benefit in at least one major outcome domain. The most consistent improvements were observed in early assessment and diagnosis and in reducing time to intervention, whereas evidence regarding mortality and other long-term patient outcomes was comparatively less consistent.

These findings are clinically important because emergency medicine is highly time dependent. The benefit of a medical device may therefore derive not simply from greater diagnostic accuracy, but from its ability to provide actionable information earlier in the patient pathway. The present findings support a conceptual pathway in which device-assisted data acquisition leads to earlier recognition, faster clinical decisions, earlier intervention, and potentially improved patient outcomes. Nevertheless, this pathway is not automatic. The clinical value of a device depends on its accuracy, availability, operator competence, integration into clinical workflows, and whether the information generated results in an appropriate change in management.

The strongest evidence in this review concerned improvements in early assessment and diagnosis. Portable monitoring and diagnostic technologies enable healthcare professionals to obtain information at the patient's location that would traditionally have required transportation to a hospital or access to centralized diagnostic services. This transition is particularly important in prehospital medicine, where clinicians often have limited diagnostic information and must make decisions under time pressure and challenging environmental conditions.

POCUS provides a clear example of this transition. In the present review, ultrasound was the most frequently evaluated device category and was associated with improvements in diagnostic confidence and identification of conditions such as cardiac dysfunction, pneumothorax, pulmonary congestion, and internal bleeding. These findings are consistent with recent evidence demonstrating the feasibility and diagnostic contribution of prehospital POCUS. Taheri et al. (2025), for example, reported that prehospital POCUS contributed to the diagnosis and management of patients with acute non-traumatic dyspnea, particularly in identifying acute heart failure, although the authors also emphasized the limited quality of much of the available evidence. Similarly, broader emergency-department evidence indicates that POCUS can achieve useful diagnostic performance across multiple conditions and support procedural interventions (Popat et al., 2024).

An important implication is that the benefits of portable devices arise partly from moving diagnostic capability closer to the patient. Rather than transporting the patient to a diagnostic resource before obtaining clinically useful information, portable technologies allow the diagnostic process to begin at the emergency scene, inside the ambulance, or immediately after arrival at the emergency department. Such decentralization may be particularly valuable in rural areas, long transport intervals, disasters, or healthcare systems where access to advanced facilities is limited.

The finding that 26 studies reported improvements in time-related outcomes is particularly relevant. For emergency conditions such as cardiac arrest, myocardial infarction, respiratory failure, severe hemorrhage, and shock, relatively short delays can influence subsequent management. Medical devices that reduce the interval between patient contact and actionable information may therefore improve the efficiency of the entire emergency-care pathway.

This interpretation is supported by previous systematic evidence regarding point-of-care testing. Rahsepar et al. (2022) reviewed point-of-care technologies in emergency care and found that their use was generally associated with faster clinical decision-making and shorter times to urgent interventions, although substantial methodological heterogeneity existed among studies.

Prehospital electrocardiography also demonstrates how a relatively established medical device can influence treatment beyond simple diagnosis. Moxham et al. (2024) found in a systematic review and

meta-analysis of 17 observational studies involving 4,306 patients with ST-elevation myocardial infarction that prehospital digital ECG transmission was associated with reductions in both door-to-device and first-medical-contact-to-device times. This illustrates an important principle identified in the present review: the greatest benefit may occur when a device is integrated into a broader care pathway rather than functioning as an isolated technology. ECG acquisition alone provides information; ECG acquisition combined with rapid transmission, specialist interpretation, and early catheterization-laboratory activation can change the timing of definitive treatment.

The findings also highlight the importance of medical devices as decision-support tools rather than replacements for clinical expertise. Twenty-three of the 31 studies examining clinical decision-making or workflow reported beneficial effects. Devices influenced decisions related to treatment initiation, patient prioritization, transport destination, escalation of care, and specialist activation.

This represents a significant development in the role of paramedics. Modern prehospital practice increasingly involves complex assessment and decision-making rather than transportation alone. Portable ECG, capnography, ultrasound, point-of-care biochemical testing, and connected monitoring technologies can provide paramedics with physiological and diagnostic information that was historically available predominantly within hospital environments.

However, more information does not necessarily result in better decisions. Device output must be interpreted within the clinical context, particularly when sensitivity and specificity are imperfect. False-positive findings may result in unnecessary interventions or inappropriate destination decisions, whereas false-negative results may generate false reassurance. Accordingly, medical devices should augment structured clinical assessment rather than replace it.

Telemedicine-enabled devices extend this model by allowing information generated in the prehospital setting to be shared with hospital-based clinicians. The present review identified benefits related to specialist consultation, communication, and preparation of receiving hospitals. This may reduce the separation between prehospital and hospital care and create a more continuous emergency-care pathway. Janerka et al. (2023) identified 28 studies involving 20 prehospital telehealth platforms and reported potential benefits for patients, clinicians, and healthcare organizations. However, technical, clinical, and organizational barriers remained important, particularly network connectivity and implementation challenges. Thus, the effectiveness of connected devices depends not only on the medical device itself but also on the digital infrastructure surrounding it.

A useful future model of emergency care may therefore involve continuous transmission of physiological measurements, ECG findings, imaging, and other point-of-care data from the ambulance to the receiving hospital. This would allow specialist teams to prepare before arrival and could potentially shorten the transition between prehospital assessment and definitive hospital treatment.

Although improvements in diagnostic, operational, and time-based outcomes were relatively consistent, the relationship between medical-device use and patient-centered outcomes was less certain. Fourteen of the 22 studies assessing direct patient outcomes demonstrated significant benefits. This lower proportion should not necessarily be interpreted as evidence that devices have little effect on patients. Instead, several methodological explanations are possible.

First, many studies were not adequately powered to detect differences in mortality or long-term outcomes. Second, patient outcome is determined by multiple factors occurring after the initial intervention, including disease severity, transport time, hospital resources, specialist availability, and subsequent treatment. Consequently, a device may significantly reduce diagnostic delay without producing a measurable mortality effect within a relatively small study.

This distinction is also apparent in the POCUS literature. Taheri et al. (2025) found evidence supporting diagnostic and therapeutic contributions of prehospital ultrasound in acute dyspnea but insufficient evidence demonstrating improved prognosis. Future studies should therefore distinguish between device performance, changes in clinical management, and ultimate patient outcomes rather than assuming that improvement in one necessarily guarantees improvement in another.

The results indicate that implementation factors substantially influence device effectiveness. Training was particularly important for interpretation-dependent technologies such as ultrasound. In contrast, devices producing relatively standardized numerical or automated outputs may require less complex interpretation, although competency remains necessary.

Medical devices used in emergency settings must also function under conditions that differ considerably from controlled hospital environments. Equipment may be exposed to movement, noise, limited lighting,

temperature variation, restricted space, contamination, and unstable network connectivity. Therefore, portability alone is insufficient. Effective emergency devices should combine portability with durability, rapid startup, adequate battery performance, simple user interfaces, reliable measurements, and compatibility with other clinical systems.

The importance of training also suggests that procurement decisions should not focus solely on purchasing equipment. Introduction of new technology should include competency standards, structured education, simulation, periodic reassessment, maintenance procedures, and clinical governance. This is particularly important for devices whose performance is strongly operator dependent.

The next stage of emergency medical-device development is likely to involve increasing integration between diagnostic devices, electronic records, telemedicine, and artificial intelligence. AI and machine-learning approaches are already being investigated in prehospital care for tasks such as prediction, triage, physiological monitoring, and clinical decision support (Chee et al., 2023). Nevertheless, technological innovation should be evaluated according to its clinical contribution rather than novelty alone.

Future emergency systems could integrate multiple data streams, including ECG signals, oxygen saturation, capnography, blood pressure, ultrasound findings, and point-of-care laboratory values, into a common decision-support environment. Such systems may help identify deterioration earlier and facilitate communication between paramedics, emergency physicians, and specialist teams. However, greater connectivity also creates concerns involving cybersecurity, patient privacy, interoperability, data accuracy, and excessive dependence on automated recommendations.

Taken together, the findings suggest that medical devices are increasingly becoming integral components of early emergency care. Their greatest contribution appears to lie in reducing information delays between initial patient contact and clinical action. Portable and connected technologies can support earlier recognition of critical conditions, enable more informed decisions, improve communication, and accelerate treatment pathways. However, the magnitude of benefit is strongly influenced by the clinical context and the surrounding system of care.

Medical devices should therefore not be viewed as stand-alone solutions. Their effectiveness depends on an integrated combination of appropriate technology, trained healthcare professionals, evidence-based protocols, reliable digital infrastructure, and rapid access to definitive treatment. When these components are aligned, medical devices have the potential to strengthen the capabilities of paramedics and other emergency healthcare professionals and contribute meaningfully to earlier and more effective emergency intervention.

5. Implications

The findings of this review have important implications for prehospital and emergency-care practice. Medical devices appear to provide their greatest value when they reduce the time between patient assessment and clinically meaningful action. Accordingly, ambulance services and emergency departments should prioritize devices that provide rapid, reliable, and actionable information and that can be incorporated directly into established emergency-care pathways.

For paramedics and other frontline healthcare professionals, technologies such as portable electrocardiography, point-of-care ultrasound, capnography, pulse oximetry, point-of-care laboratory testing, and portable monitoring systems may expand the scope of assessment that can be performed before definitive hospital treatment. However, implementation should be accompanied by structured education, competency assessment, and continuing training. This is particularly important for operator-dependent technologies such as ultrasound, where diagnostic performance may vary according to experience and training.

Medical-device use should also be supported by clear clinical protocols specifying when a device should be used, how findings should be interpreted, and what clinical actions should follow. The objective should not be to increase the number of devices available to emergency personnel, but to ensure that each device contributes to faster recognition, better decision-making, or more timely treatment.

Healthcare organizations should consider medical-device procurement as part of a wider system of emergency-care improvement rather than as an isolated technological investment. Decisions regarding device adoption should take into account clinical effectiveness, portability, durability, maintenance requirements, battery performance, staff training, interoperability, and cost-effectiveness.

Integration between prehospital devices and hospital information systems is particularly important. The ability to transmit ECGs, physiological measurements, imaging findings, and point-of-care results before hospital arrival may allow receiving teams to activate appropriate clinical pathways and prepare resources in advance. Such integration could improve continuity between ambulance services and emergency departments and reduce unnecessary duplication of assessments.

Organizations should also establish mechanisms for monitoring device performance, maintenance, adverse events, utilization, and clinical outcomes after implementation.

At the policy level, the increasing use of portable and connected medical devices requires clear standards for clinical governance, data security, interoperability, professional competency, and device maintenance. Regulatory and healthcare authorities should develop minimum requirements for the safe use of emergency medical technologies, particularly those that transmit patient information or incorporate automated decision-support functions.

Standardized training and certification may be particularly important for advanced diagnostic technologies used by paramedics. Policies should also address patient privacy, cybersecurity, data ownership, and the secure transmission of clinical information between ambulances, emergency departments, and specialist services.

Future research should move beyond evaluating technical accuracy alone and focus on whether medical devices produce meaningful changes in clinical management and patient outcomes. Larger multicenter prospective studies are required to determine whether improvements in diagnostic speed and treatment timing translate into reductions in mortality, complications, hospital length of stay, or neurological disability.

Further research is also needed on cost-effectiveness, usability, human factors, rural and resource-limited settings, and the integration of artificial intelligence with emergency medical devices. Standardized outcome measures would improve comparability across studies and support future meta-analyses. Ultimately, future evaluation should determine not only whether a device works, but whether it improves the overall emergency-care pathway and delivers measurable benefit to patients.

6. Limitations

This systematic review has several limitations that should be considered when interpreting its findings. First, substantial heterogeneity was present across the included studies in terms of device type, clinical setting, patient population, professional users, study design, and reported outcomes. The reviewed technologies ranged from point-of-care ultrasound and electrocardiography to respiratory monitoring, point-of-care laboratory testing, telemedicine, and resuscitation devices. Because these technologies serve different clinical purposes, direct comparison across studies was limited and a single pooled meta-analysis was not considered appropriate.

Second, the methodological quality of the included evidence varied. Although a proportion of studies were assessed as high quality, many were observational, single-center, or based on relatively small samples. Common limitations included inadequate adjustment for confounding, limited blinding, inconsistent operator training, and differences in outcome definitions. These factors may reduce the certainty and generalizability of the findings.

Third, many studies focused on intermediate outcomes such as diagnostic accuracy, time to intervention, clinical decision-making, or workflow efficiency rather than long-term patient-centered outcomes. Consequently, although medical devices frequently appeared to improve early assessment and treatment processes, the extent to which these improvements translate into lower mortality, fewer complications, improved neurological outcomes, or better long-term recovery remains uncertain.

Fourth, only English-language studies published between January 2015 and September 2026 were included. Relevant evidence published in other languages or before the selected period may therefore have been excluded. Publication bias is also possible, as studies demonstrating favorable device performance may be more likely to be published than studies reporting neutral or negative findings.

Finally, emergency medical technology is developing rapidly. Devices, software, connectivity systems, and artificial intelligence capabilities may evolve faster than the publication cycle of clinical research. Therefore, some technologies included in this review may already have been modified or replaced by newer versions. Future reviews should be updated regularly and should incorporate standardized outcome measures, stronger comparative designs, and broader evaluation of effectiveness, safety, cost, usability, and long-term patient outcomes.

Conclusion

Medical devices have become increasingly important in supporting paramedics and healthcare professionals during the earliest stages of emergency care. The findings of this systematic review indicate that portable and point-of-care technologies can improve rapid assessment, diagnostic support, physiological monitoring, clinical decision-making, and the timeliness of emergency interventions. The most consistent benefits were observed in reducing delays to actionable clinical information and supporting earlier treatment, while evidence for direct improvements in mortality and long-term patient outcomes was less consistent.

Technologies such as point-of-care ultrasound, portable electrocardiography, defibrillation systems, capnography, pulse oximetry, portable ventilators, point-of-care laboratory testing, and telemedicine-enabled devices can extend diagnostic and therapeutic capabilities beyond traditional hospital settings. Their effectiveness, however, depends not only on technical performance but also on staff competency, appropriate clinical protocols, device reliability, interoperability, and integration with existing emergency-care pathways.

Future research should focus on large multicenter studies, standardized outcome measures, cost-effectiveness, usability, and patient-centered outcomes. Greater attention is also needed to the safe integration of connected technologies and artificial intelligence into prehospital practice.

Overall, medical devices have substantial potential to strengthen early emergency intervention when used as part of an integrated system combining appropriate technology, trained professionals, reliable infrastructure, and evidence-based clinical decision-making.

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