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Knowledge, Skills, And Devices: A Review Of Paramedics' Familiarity With Cardiopulmonary Resuscitation Equipment In Pre-Hospital Care

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Abstract

Cardiopulmonary resuscitation (CPR) is a cornerstone of emergency medicine, and paramedics often serve as the first responders in out-of-hospital cardiac arrest cases. The effectiveness of CPR is increasingly influenced by the use of mechanical devices and adjunctive technologies, such as automated external defibrillators (AEDs), mechanical chest compression systems (e.g., LUCAS, AutoPulse), and airway management tools. Familiarity with these devices, including training, frequency of use, and confidence levels, is critical for optimizing patient outcomes. This review explores the current evidence on paramedics' knowledge and skills in using CPR devices, the barriers to device adoption, and the clinical implications of familiarity for survival rates and neurological outcomes. By synthesizing existing literature, the review highlights training methodologies, systems of care integration, and the importance of continuous professional development. The findings suggest that high familiarity and competence improve performance during resuscitation, reduce human error, and enhance overall quality of pre-hospital care. Future directions include developing standardized training modules, leveraging simulation-based education, and integrating digital feedback systems into paramedic practice.

Keywords: Paramedics, Cardiopulmonary Resuscitation, Familiarity, CPR Devices, Pre-Hospital Care, Training, Outcomes.

1. Introduction

Out-of-hospital cardiac arrest (OHCA) remains a global public health challenge, with survival rates ranging between 5% and 20% depending on the system of care and timeliness of interventions (Gräsner et al., 2021). Early initiation of high-quality cardiopulmonary resuscitation (CPR) and timely defibrillation are the most critical determinants of survival, as emphasized in the 2020 American Heart Association (AHA) guidelines (Kleinman et al., 2020). Paramedics, as frontline emergency medical service (EMS) providers, play a pivotal role in delivering these life-saving interventions in pre-hospital settings.

Technological innovations in CPR have introduced devices such as automated external defibrillators (AEDs), mechanical chest compression devices (e.g., LUCAS, AutoPulse), and airway management tools that are now integral to advanced life support protocols. These devices are designed to improve the consistency and quality of resuscitation efforts, reduce rescuer fatigue, and enable multitasking during emergencies (Soar et al., 2021). However, the effectiveness of such technologies is heavily dependent on the paramedics' familiarity, confidence, and skill in using them.

Familiarity extends beyond simple device availability—it encompasses cognitive knowledge, psychomotor skills, and experiential learning through frequent use and training. Studies suggest that inadequate training and low exposure to CPR devices may hinder their optimal use during emergencies, ultimately compromising patient outcomes (Couper et al., 2019). Conversely, paramedics who are well-trained and confident in using resuscitation equipment are more likely to achieve higher-quality compressions, quicker defibrillation, and improved patient survival rates (Perkins et al., 2021).

The concept of device familiarity also intersects with system-level factors, including EMS training protocols, simulation-based education, and access to continuous professional development. In many EMS systems, disparities in training frequency, equipment availability, and standardization of protocols have created variability in paramedic performance and patient outcomes (Olasveengen et al., 2021). Addressing these gaps is critical, as increasing familiarity with CPR devices not only enhances technical competence but also strengthens decision-making under pressure and teamwork during resuscitation.

This review aims to synthesize current evidence on paramedics' familiarity with CPR devices in pre-hospital care. Specifically, it explores the knowledge and skills required to use AEDs, mechanical chest compression systems, and airway management devices; examines the influence of familiarity on clinical outcomes; and highlights strategies for improving training and system integration. By doing so, this review seeks to provide insights for policymakers, educators, and EMS leaders to enhance paramedic preparedness and ultimately improve survival from OHCA.

2. CPR Devices in Pre-Hospital Care

Pre-hospital care of cardiac arrest patients increasingly relies on advanced devices that complement manual resuscitation efforts. These devices are designed to standardize CPR quality, optimize survival outcomes, and mitigate rescuer fatigue. Paramedics, as primary users, must demonstrate familiarity with their operation, limitations, and integration into protocols to ensure maximum benefit (Soar et al., 2021).

Automated external defibrillators have revolutionized early defibrillation in both public access and professional use. AEDs are programmed to analyze cardiac rhythms and deliver shocks when indicated, thereby reducing human error in rhythm interpretation (Kleinman et al., 2020). For paramedics, AEDs are often the first-line defibrillation device in the pre-hospital environment, particularly in basic life support (BLS) contexts or when advanced monitoring equipment is unavailable. Familiarity with AED functions, electrode placement, and troubleshooting is critical for minimizing "hands-off" time and improving return of spontaneous circulation (ROSC) (Nolan et al., 2021). Studies have shown that paramedics who receive frequent AED refresher training perform faster and more accurate defibrillation, which directly correlates with improved survival (Couper et al., 2019).

Manual chest compressions remain the gold standard, but fatigue and variability in compression depth, rate, and recoil can reduce effectiveness over time. Mechanical chest compression devices such as the **LUCAS** (Lund University Cardiac Assist System) and **AutoPulse** are designed to deliver consistent, uninterrupted compressions. Evidence suggests that these devices can be particularly beneficial in complex environments such as during patient transport, prolonged resuscitation, or when staffing is limited (Perkins et al., 2021). However, their effectiveness is not solely determined by device mechanics—paramedic familiarity with deployment, calibration, and minimizing pauses during transition is crucial (Grunau et al., 2022). Randomized trials indicate no significant improvement in overall survival with mechanical devices compared to manual compressions, but higher-quality compressions and reduced rescuer fatigue remain notable advantages when devices are used appropriately (Link et al., 2021).

Effective ventilation is another pillar of resuscitation. In pre-hospital settings, paramedics commonly use bag-valve masks (BVMs), supraglottic airway devices (SGAs), and endotracheal intubation (ETI). Familiarity with airway management devices is strongly associated with success rates and reduced complications such as aspiration or hypoxia (Wang et al., 2018). SGAs (e.g., laryngeal mask airway, i-gel) have gained prominence due to their relative ease of insertion, particularly when ETI expertise or conditions are suboptimal (Soar et al., 2021). Evidence suggests that paramedics with higher exposure

and training demonstrate shorter insertion times and higher success rates, translating into better patient outcomes (Benger et al., 2018).

The introduction of real-time CPR feedback devices, which provide visual and auditory cues for compression depth, rate, and recoil, has improved adherence to resuscitation guidelines. These technologies, integrated into defibrillators or as stand-alone sensors, help paramedics adjust performance dynamically during resuscitation efforts (Meaney et al., 2013; Olasveengen et al., 2021). Familiarity with interpreting feedback and integrating it into resuscitation workflow is essential for ensuring consistent CPR quality.

The availability of advanced CPR devices alone does not guarantee improved outcomes. Research consistently shows that paramedic familiarity, skill, and confidence in using devices determine their effectiveness in real-world scenarios. Systems that incorporate frequent refresher training, simulation-based practice, and protocol-driven deployment of CPR devices have reported higher-quality CPR delivery and better patient outcomes (Gräsner et al., 2021).

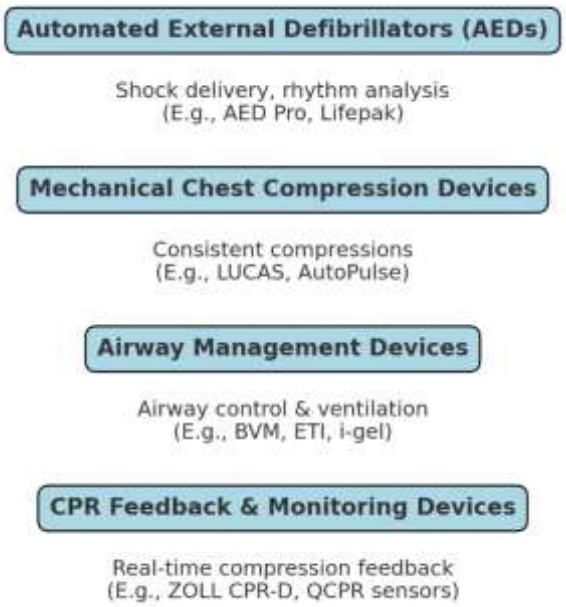

Figure 1: CPR Devices in Pre-Hospital Care

which visually categorizes the major types of devices (AEDs, mechanical compression, airway management, and feedback systems) along with examples and their main functions.

3. Paramedic Training and Familiarity

The effective use of cardiopulmonary resuscitation (CPR) devices by paramedics is highly dependent on the depth and frequency of their training. Familiarity with devices—encompassing both theoretical knowledge and psychomotor skills—is a crucial determinant of performance during out-of-hospital cardiac arrest (OHCA) scenarios. Training ensures that paramedics are not only capable of operating advanced resuscitation equipment, but also confident in integrating these devices into dynamic, high-stress environments.

Traditional training in CPR device use often relies on classroom-based instruction, standardized manuals, and instructor-led demonstrations. While these methods provide foundational knowledge, they are limited in maintaining long-term retention of psychomotor skills. Studies indicate that paramedics who rely solely on traditional didactic training may experience rapid skill decay, particularly in device deployment and troubleshooting (Wik et al., 2019).

Simulation-based training has emerged as a gold standard for enhancing familiarity with CPR devices. High-fidelity manikins and scenario-based exercises allow paramedics to replicate real-world emergencies, where they practice using AEDs, mechanical compression devices, and airway adjuncts under time-critical conditions. Evidence demonstrates that simulation-based education not only improves technical proficiency but also enhances decision-making, teamwork, and confidence (Greif et al., 2020). Moreover, repeated simulation exposure helps maintain long-term competence compared to one-off training sessions (Plant & Taylor, 2021).

The frequency of training is directly linked to device familiarity and retention. Studies suggest that paramedics who participate in quarterly or biannual training sessions perform significantly better than those who undergo annual recertification (Bhanji et al., 2015). Infrequent exposure to certain devices—particularly mechanical chest compression systems and advanced airway tools—can limit paramedic confidence and increase error rates during emergencies (Olasveengen et al., 2021). Regular refresher courses, combined with on-the-job reinforcement, are essential for sustaining competence.

Despite the recognized importance of training, barriers exist. Limited access to advanced CPR devices in rural or resource-limited EMS systems restricts opportunities for hands-on experience (Gräsner et al., 2021). Budgetary constraints may prevent agencies from acquiring training equipment or providing continuous professional development. Additionally, variability in national and regional certification requirements contributes to inconsistency in paramedic familiarity with device use.

Continuing professional development plays a vital role in bridging gaps between initial certification and ongoing practice. CPD programs often integrate blended learning, combining online modules with practical workshops, which reinforce knowledge and provide flexible opportunities for skill maintenance (Liaw et al., 2019). Structured CPD initiatives that incorporate peer feedback, post-event debriefings, and evidence-based updates foster paramedics' confidence and adaptability in using CPR devices during pre-hospital care.

Training standards vary across EMS systems globally. For example, paramedics in North America often undergo advanced training in mechanical CPR devices and airway management, whereas many European systems prioritize supraglottic devices and AED familiarity (Soar et al., 2021). This diversity underscores the importance of harmonizing international training guidelines to ensure consistency and comparability in paramedic performance across healthcare systems.

Table 1: Training Approaches and Outcomes

Training Approach	Description	Impact on Familiarity and Outcomes	Supporting References
Traditional (Classroom/Didactic)	Instructor-led lectures, manuals, and demonstrations; focuses on theoretical understanding.	Provides baseline knowledge but limited long-term retention of device skills.	Wik et al., 2019
Simulation-Based Training	Hands-on practice with CPR devices in controlled, scenario-based environments.	Improves technical proficiency, teamwork, and confidence under pressure.	Greif et al., 2020
High-Fidelity Manikin Scenarios	Advanced simulation using high-tech manikins replicating real OHCA conditions.	Enhances realism, decision-making, and psychomotor skill retention.	Plant & Taylor, 2021

Table 2 Training Approaches and Outcomes, which compares traditional, simulation-based, high-fidelity, CPD, and on-the-job refresher training methods. It highlights their descriptions, impacts on paramedic familiarity, and supporting references.

4. Systems and Operational Considerations

The effective integration of cardiopulmonary resuscitation (CPR) devices into pre-hospital emergency care is not solely dependent on paramedic knowledge and skills. System-level and operational factors play a critical role in determining whether these devices are deployed optimally and whether their use translates into improved patient outcomes. Familiarity with CPR equipment is closely tied to how emergency medical service (EMS) systems structure protocols, allocate resources, and support team-based operations.

Operational protocols provide the framework within which paramedics apply CPR devices in the field. Standard operating procedures (SOPs) outline when and how devices such as automated external defibrillators (AEDs), mechanical chest compression devices, and advanced airway tools should be deployed. Well-designed protocols help reduce variability, ensuring device use is consistent across providers and situations (Soar et al., 2021). However, systems without clear guidance or with overly complex protocols may inadvertently delay device deployment and limit paramedic familiarity (Link et al., 2021).

Resuscitation efforts are inherently team-based, requiring clear communication and coordination. Paramedic familiarity with CPR devices enhances team efficiency by reducing time lost to equipment setup, troubleshooting, or miscommunication. Research indicates that structured team training, which designates specific roles (e.g., airway management, chest compressions, device operation), improves resuscitation flow and reduces interruptions in compressions (Greif et al., 2020). Operational familiarity thus goes beyond individual competence—it also relates to how teams coordinate during high-stakes scenarios.

Operational considerations directly influence the timeliness of resuscitation interventions. Device familiarity can shorten time to defibrillation, minimize pauses in chest compressions during device transitions, and reduce delays in establishing advanced airways (Nolan et al., 2021). Systems that emphasize rapid deployment training and integrate devices into “pit-crew” style resuscitation models report significant improvements in return of spontaneous circulation (ROSC) rates (Meaney et al., 2013). Conversely, when devices are rarely used or poorly integrated into workflows, deployment may prolong response times and negate potential benefits.

Differences in operational contexts also shape device familiarity. In urban settings, where paramedics are exposed to higher call volumes and more frequent cardiac arrest cases, familiarity with CPR devices is naturally reinforced through practice. In contrast, rural EMS providers may have fewer opportunities to use advanced equipment, which can lead to lower confidence and slower device deployment (Gräsner et al., 2021). These disparities highlight the need for targeted training and system adaptations, such as mobile simulation units or shared regional resources, to ensure equitable familiarity across different settings.

Access to CPR devices and training opportunities is often determined by system-level funding and resource allocation. Agencies with limited budgets may prioritize core medical equipment over advanced devices like mechanical compression systems or high-fidelity feedback tools. Additionally, inadequate maintenance, device availability, or logistical challenges (e.g., transporting mechanical devices) can reduce their operational use (Grunau et al., 2022). Effective system design therefore requires investment not only in device acquisition but also in continuous training, maintenance, and evaluation of outcomes.

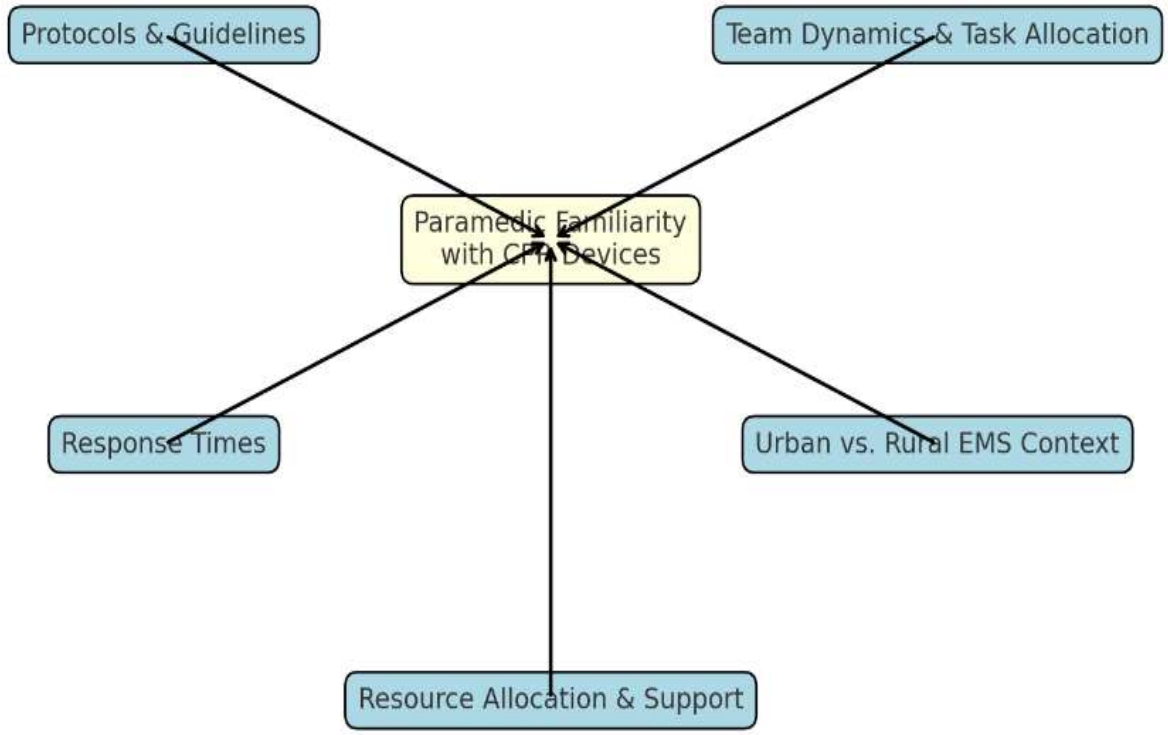

Figure 2: Systems and Operational Factors Influencing Paramedic Familiarity

which shows how protocols, team dynamics, response times, resource allocation, and EMS context (urban vs. rural) all feed into paramedic familiarity with CPR devices.

5. Clinical Outcomes Associated with Familiarity

The ultimate measure of paramedics' familiarity with cardiopulmonary resuscitation (CPR) devices lies in its impact on patient-centered outcomes. Evidence indicates that proficiency in device use—supported by frequent training and exposure—correlates strongly with improved return of spontaneous circulation (ROSC), survival to hospital discharge, and favorable neurological recovery. Conversely, unfamiliarity, delayed deployment, or misuse of devices may negate their potential benefits and even compromise outcomes.

ROSC is often the first measurable indicator of successful resuscitation. Studies demonstrate that when paramedics are familiar with automated external defibrillators (AEDs), defibrillation occurs more quickly and consistently within the recommended timeframes, leading to higher ROSC rates (Kleinman et al., 2020). Similarly, familiarity with mechanical chest compression devices reduces interruptions during device placement, thereby improving coronary perfusion pressures and the likelihood of ROSC (Perkins et al., 2021).

Familiarity with CPR devices contributes to smoother transitions of care from the pre-hospital to in-hospital environment. Research has shown that paramedics with higher confidence in using advanced airway devices, such as supraglottic airways (SGAs), achieve faster airway control, which stabilizes oxygenation and increases chances of survival to hospital admission (Wang et al., 2018). Moreover, EMS systems with well-integrated device training protocols report higher rates of survival to hospital discharge, demonstrating the systemic benefits of paramedic familiarity (Gräsner et al., 2021).

Beyond survival, neurological outcomes are a critical endpoint in cardiac arrest care. High-quality compressions, achieved through correct use of mechanical compression devices and feedback monitors, are linked to improved cerebral perfusion and reduced neurological impairment post-resuscitation (Meaney et al., 2013). When paramedics are adept at integrating real-time feedback devices into

resuscitation, adherence to compression guidelines improves, directly impacting neurological recovery rates (Olasveengen et al., 2021).

Several randomized controlled trials have compared manual chest compressions with mechanical devices. While outcomes remain mixed, findings consistently emphasize the role of user familiarity in determining success. For example, Perkins et al. (2021) reported no significant improvement in survival when mechanical devices were deployed without adequate training. However, systems with strong paramedic familiarity demonstrated reductions in pauses, improved compression depth consistency, and fewer operator errors. This highlights that device effectiveness is not absolute but mediated by the operator's level of familiarity.

Despite growing literature, inconsistencies exist in measuring outcomes directly tied to familiarity. Variability across EMS systems, differences in device availability, and heterogeneity in training standards complicate the interpretation of outcomes. More robust studies are needed to isolate the impact of paramedic familiarity from other confounding variables, such as response time and patient comorbidities (Grunau et al., 2022).

Table 2. Key Studies on Paramedic Familiarity with CPR Devices and Clinical Outcomes

Author/Year	Device Studied	Sample/Setting	Key Findings
Kleinman et al., 2020	AEDs	U.S. EMS database	Faster defibrillation and higher ROSC when paramedics trained and familiar.
Perkins et al., 2021	Mechanical compression (LUCAS, AutoPulse)	UK multicenter trial	Familiarity improved CPR quality, reduced pauses; no survival benefit w/o training.
Wang et al., 2018	Airway management devices	North American EMS	Familiarity with SGAs improved airway control success and survival to admission.
Gräsner et al., 2021	Mixed CPR devices	EuReCa TWO (Europe)	Systems with stronger device integration and training achieved higher discharge survival.
Olasveengen et al., 2021	CPR feedback devices	European EMS	Real-time feedback, when used by familiar paramedics, improved CPR adherence and neurological outcomes.

Discussion

The findings of this review highlight the critical role that familiarity with cardiopulmonary resuscitation (CPR) devices plays in improving pre-hospital care outcomes. While the availability of automated external defibrillators (AEDs), mechanical chest compression devices, airway adjuncts, and feedback technologies has expanded significantly over the past two decades, their effectiveness is highly dependent on paramedics' knowledge, confidence, and operational competence in their use. This underscores the importance of considering familiarity as both an educational and systemic issue within emergency medical services (EMS).

Familiarity with devices directly influences CPR quality by reducing delays in deployment, ensuring correct usage, and minimizing performance errors. The evidence reviewed indicates that paramedics who undergo frequent training, particularly simulation-based education, demonstrate higher proficiency and confidence in device operation (Greif et al., 2020). This, in turn, results in improved adherence to resuscitation guidelines, more consistent chest compressions, and faster defibrillation. Conversely, lack of familiarity or infrequent exposure may negate the potential benefits of these devices, as observed in randomized trials of mechanical chest compression devices where outcomes varied depending on operator expertise (Perkins et al., 2021).

The discussion of systems and operational factors reinforces that familiarity cannot be understood solely at the individual level. EMS systems that invest in structured training programs, integrate devices into standard operating protocols, and emphasize team-based resuscitation approaches foster greater familiarity and more efficient deployment during cardiac arrest events (Soar et al., 2021). By contrast, systems with limited resources or inconsistent training standards often face challenges in ensuring widespread proficiency. Rural EMS agencies, for instance, may struggle with lower exposure to cardiac arrest cases, resulting in slower device deployment and reduced familiarity compared to urban providers (Gräsner et al., 2021).

The evidence suggests a clear link between paramedic familiarity and improved clinical outcomes such as return of spontaneous circulation (ROSC), survival to hospital admission, and favorable neurological recovery. However, the relationship is complex and influenced by multiple interacting variables, including patient characteristics, response times, and system-level resources (Grunau et al., 2022). It is noteworthy that while device availability alone does not guarantee improved outcomes, the combination of availability with high familiarity appears to yield substantial benefits. Thus, familiarity should be considered a modifiable factor in efforts to enhance survival rates from out-of-hospital cardiac arrest.

Despite progress, there remain gaps in the literature regarding the measurement of familiarity and its direct impact on outcomes. Most studies rely on proxies such as training frequency, skill assessment, or self-reported confidence, rather than standardized measures of familiarity. Furthermore, heterogeneity across EMS systems complicates the comparison of results across studies. There is a need for more rigorous, multi-center studies that isolate familiarity as an independent variable, while accounting for other confounders such as response times, patient demographics, and system-level differences.

To advance the field, EMS systems should prioritize structured, recurring training that emphasizes both technical and cognitive aspects of device use. Simulation-based training, combined with real-time feedback and post-event debriefing, can reinforce familiarity and improve performance under pressure. Additionally, innovations such as virtual reality training platforms and AI-driven CPR feedback devices may provide scalable solutions for maintaining familiarity in diverse settings. Policymakers and system leaders should also consider harmonizing international training standards to reduce variability in familiarity levels across different regions.

Conclusion

Familiarity with cardiopulmonary resuscitation (CPR) devices among paramedics is a critical determinant of both the quality of resuscitation efforts and patient outcomes in pre-hospital cardiac arrest care. This review demonstrates that knowledge, confidence, and repeated exposure to devices such as automated external defibrillators (AEDs), mechanical chest compression systems, airway management tools, and real-time feedback monitors significantly enhance paramedic performance. Improved familiarity translates into reduced delays in intervention, higher adherence to resuscitation guidelines, and better clinical outcomes, including higher rates of return of spontaneous circulation (ROSC), survival to hospital discharge, and favorable neurological recovery.

However, familiarity is shaped not only by individual training but also by system-level factors, including protocol integration, team dynamics, resource availability, and regional EMS contexts. While advanced devices offer great potential, their benefits can only be fully realized when paramedics are adequately trained, supported, and confident in their use.

To maximize the impact of CPR devices in pre-hospital care, EMS systems must invest in structured, recurring, and simulation-based training, supported by continuous professional development and feedback mechanisms. Moreover, harmonizing training standards across regions and ensuring equitable resource distribution can reduce variability in device use and outcomes. Future research should focus on developing standardized measures of familiarity and evaluating its direct effect on survival and neurological recovery.

Ultimately, strengthening paramedics' familiarity with CPR devices represents a highly modifiable factor in improving survival from out-of-hospital cardiac arrest, reinforcing the central role of training and system design in saving lives.

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