Submitted: 06 February, 2024 Accepted: 25 March, 2024 Online Published: 14 May, 2024 DOI:10.22514/sv.2024.063

Open Access
Signa Vitae

ORIGINAL RESEARCH

Enhancing EMS readiness: a pilot evaluation of CPR proficiency and training dynamics among paramedics in Poland

Łukasz Maciejewski[1], Katarzyna Naylor[2,*], Konrad Szast[3], Ahmed M. Al-Wathinani[4,*], Mohammed Aljuaid[5], Krzysztof Goniewicz[6]

[1]The Regional Ambulance Service in Lublin, 20-043 Lublin, Poland
[2]Independent Unit of Emergency Medical Services and Specialist Emergency, Medical University of Lublin, 20-093 Lublin, Poland
[3]Lab of Specialistic and Tactical Simulation, Medical University of Lublin, 20-093 Lublin, Poland
[4]Department of Emergency Medical Services, Prince Sultan bin Abdulaziz College for Emergency Medical Services, King Saud University, 11451 Riyadh, Saudi Arabia
[5]Department of Health Administration, College of Business Administration, King Saud University, 11451 Riyadh, Saudi Arabia
[6]Department of Security, Polish Air Force University, 08-521 Deblin, Poland

***Correspondence**
ahmalotaibi@ksu.edu.sa
(Ahmed M. Al-Wathinani);
katarzyna.naylor@umlub.pl
(Katarzyna Naylor)

Abstract

Effective Cardiopulmonary Resuscitation (CPR) is crucial for improving outcomes in cardiac arrest situations. This study aims to assess the proficiency of paramedics in the Lubelskie Voivodeship, Poland, in performing CPR, focusing on compression depth and ventilation techniques. A cohort of 69 paramedics was engaged in this analysis, utilizing an Ambu manikin to simulate CPR scenarios. This setup allowed for a comprehensive assessment of each participant's technique, focusing on compression depth consistency and the efficiency and accuracy of ventilation techniques. The study revealed that paramedics demonstrated commendable proficiency in chest compression, achieving an average depth of 58.48 mm, which falls within the recommended range of 50 mm to 60 mm. However, there was a notable variation in compression depths, ranging from 47 mm to 72 mm. Additionally, ventilation techniques displayed significant inconsistencies, with 87.4% of ventilations performed below the recommended volume range. Many participants also deviated from the advised compression-to-ventilation ratio, further indicating the need for enhanced guidelines adherence. While paramedics exhibit a strong foundation in CPR techniques, the observed variations and inconsistencies underline the importance of continuous and focused training. This study advocates for the development and implementation of targeted training programs to address these gaps. Such initiatives should reinforce adherence to established CPR guidelines and emphasize integrating realistic simulation experiences to improve overall CPR performance, ultimately contributing to better patient outcomes in emergencies.

Keywords

Cardiopulmonary resuscitation; Paramedic training; Chest compression; Ventilation techniques; Emergency medical services; Sudden cardiac arrest; CPR effectiveness

1. Introduction

Sudden Cardiac Arrest (SCA) remains a formidable challenge within the European medical landscape, presenting a substantial hurdle to emergency medical care [1]. The prevalence of SCA across the continent underscores its critical importance, as it stands as a leading cause of mortality, claiming countless lives each year. Despite significant advancements in medical response capabilities, the pre-hospital survival rates of SCA victims are alarmingly low, with discharge rates ranging from a mere 3% to 25% [2, 3]. This grim statistic highlights the urgent need for improved emergency interventions, particularly in the crucial minutes following an arrest, before the arrival of professional help [4].

The essence of enhancing survival rates in SCA scenarios lies in the immediate initiation and quality of cardiopulmonary resuscitation (CPR). High-quality CPR, characterized by proficient chest compressions and adequate ventilation, is acknowledged by leading health organizations such as the European Resuscitation Council (ERC) and the American Heart Association (AHA) as a cornerstone of effective emergency cardiac care [5, 6]. The EMS teams, equipped with specialized training and advanced resuscitation equipment, play a pivotal role in this critical intervention, often making the difference between life and death [7, 8].

The transition from bystander-initiated CPR to professional medical response is a critical juncture in the chain of survival for SCA victims. This phase underscores the paramount importance of paramedics within the Polish Emergency Medical Services (EMS) system. In Poland, paramedics are often the first healthcare professionals to engage with the patient in emergency settings, making their role in SCA scenarios especially significant. They are tasked with rapidly assessing the situation, initiating advanced life support measures, and ensuring the continuity of high-quality care initiated by bystanders.

However, the unique challenges Polish paramedics face in executing their duties are multifaceted—from navigating the complexities of emergency scenes to performing under the high-pressure conditions of SCA incidents. The level of engagement and the effectiveness of paramedics in these scenarios are critical factors that directly impact patient outcomes. Therefore, understanding the nuances of their roles, challenges and the standards they adhere to in emergency care is crucial for evaluating and enhancing SCA response strategies.

Polish paramedics undergo a rigorous educational and practical regimen to equip them with the skills necessary for high-stakes medical interventions. This training encompasses a variety of programs, spanning from basic emergency care to specialized resuscitation techniques, adhering to national and international standards. The duration, certifications and recent advancements in their training protocols reflect an ongoing commitment to improving emergency medical response capabilities in Poland. However, it is imperative to examine how this training translates into practice, particularly in the execution of CPR.

Polish paramedics evaluate CPR performance according to standards and guidelines that align with national expectations and international best practices [8]. These standards are designed to ensure that CPR is performed efficiently and effectively, maximizing the chances of survival for SCA victims [9, 10]. Recent guidelines update reflects an evolving understanding of optimal resuscitation techniques, emphasizing the need for continuous learning and adaptation among emergency medical professionals [11–13].

Despite these stringent training and evaluation protocols, there exists a gap in our understanding of how Polish paramedics perform CPR in real-life scenarios. Questions about the fidelity of their practice to established guidelines and the areas where their training could be further enhanced still need to be answered. This gap highlights a critical area of research and points to the potential for significant improvements in CPR outcomes.

The study proposed herein seeks to address these questions head-on. Focusing on the performance of CPR by Polish paramedics, this research aims to uncover the strengths and weaknesses in their current practice. The objective is to identify specific training and procedural gaps that, once addressed, could lead to marked improvements in the quality of CPR delivered in emergencies.

This investigation is timely and necessary, given the dynamic nature of medical emergencies and the constant advancements in resuscitation science. By assessing the current state of CPR performance among Polish paramedics, this study aims to bridge the theoretical knowledge acquired through training with the practical application of CPR techniques in emergency settings. This alignment is crucial for enhancing the effectiveness of emergency medical care and ultimately, improving patient outcomes in SCA scenarios.

As a pioneering effort, this research contributes to the global discourse on emergency medical care and provides valuable insights specific to the Polish context. By identifying potential areas for improvement in CPR training and execution, the study aims to inform and elevate the standards of emergency medical response in Poland. This endeavor promises to enhance the readiness and proficiency of EMS teams.

2. Materials and methods

2.1 Setting and participants

The study was initiated in 2018, targeting a select group of 69 paramedics from the Lubelskie Voivodeship, Poland. This cohort was explicitly chosen to allow for a comprehensive and in-depth analysis of their basic life-saving intervention skills. The selection process was based on voluntary participation, ensuring anonymity to promote candid feedback and genuine performance. Participants were active Medical Rescuers working across varied emergency settings, such as Medical Rescue Teams, Hospital Emergency Departments and Air Ambulance services, providing a diverse perspective on emergency medical practices.

2.2 Training course overview

In response to evolving medical emergency response standards, a professional development course for paramedics was structured following the regulation of the Minister of Health, dated 13 December 2019. Although the course was officially recognized post-study, the curriculum and training methodologies evaluated in 2018 predated and informed the establishment of this regulatory framework. The course spanned five-year cycles, including 48 teaching hours over 6 days. It comprised 15 hours of theoretical instruction on emergency medical service systems and communication skills, alongside 33 hours of practical training focused on emergency medical interventions and the application of modern communication technologies.

2.3 Course development and study context

This study, conducted in 2018, played a pivotal role in shaping the training framework for Polish paramedics. Insights gained from evaluating CPR performance were instrumental in developing a comprehensive professional development course formalized through the Minister of Health's regulation in December 2019. This section elucidates how the empirical data collected pre-emptively influenced the curriculum's design, ensuring it addressed real-world challenges identified through the study. It underscores the study's contribution to enhancing paramedic training, aligning it with national and international best practices in emergency medical care.

2.4 Selection process clarification

The selection process for this study was meticulously designed to ensure a diverse and representative sample of paramedics from the Lubelskie Voivodeship. Participants were recruited through an open call within the EMS community, emphasizing voluntary and anonymous participation to foster an environment of honesty and transparency. This approach was intended to attract a wide range of Medical Rescuers from various emergency service settings to participate. Detailing this process highlights our commitment to inclusivity and the pursuit of comprehensive insights into CPR proficiency across emergency medical services.

2.5 Practical training and data collection

The practical training sessions conducted at the Lublin Regional Ambulance Service's training center were pivotal in evaluating the CPR skills of the participants. Utilizing the Ambu Man manikin, equipped with sophisticated software for CPR performance analysis, participants engaged in exercises simulating real-life emergency scenarios. This hands-on approach, new to all participants, was critical in assessing their competencies in life-saving interventions, mainly chest compression and ventilation techniques. The manikin's advanced capabilities allowed for precisely evaluating each participant's adherence to CPR guidelines, bridging theoretical knowledge with practical skill application.

2.6 Method limitations

Acknowledging the pilot nature of this study, several methodological limitations were identified. The limited sample size of 69 participants, while sufficient for an in-depth initial analysis, poses challenges to the broader applicability of the findings. Moreover, using Ambu Man manikins and the standardized 6-minute CPR exercises may not encompass the variability of real-life emergency conditions, potentially affecting the study's outcomes.

2.7 Statistical analysis

Data compilation and preliminary analysis were conducted using Microsoft Excel software (MS Office 2010, Redmond, WA, USA). Advanced statistical analysis was performed using Statistica 13.1 (StatSoft Polska, Tulsa, OK, USA), with quantitative data presented through various statistical measures. The study also included a Shapiro-Wilk normality test to assess the distribution of the variables.

3. Results

3.1 Demographics and professional background of participants

This study analyzed CPR techniques among 69 paramedics in the Lubelskie Voivodeship, characterized by a predominantly male demographic (97.10%) and an age range of 29 to 59 years, with an average age of 40 years. More indicative of the participants' CPR experience than their wide age range is the length of service, which varied from 7 to 36 years, with an average of 17.74 years. This variation in service length represents a broad spectrum of experience in emergency medical services, from relatively new paramedics to highly seasoned professionals. Although the study was conducted within a singular regional setting, limiting the diversity of employment settings (with a significant majority working in similar environments), the range of service years provides valuable insights into the impact of experience on CPR performance. The detailed breakdown in Table 1 supports a thorough analysis of CPR performance by providing insight into the participant pool's composition.

TABLE 1. Characteristics of the study group (n = 69).

Characteristic	Detail	Statistics
Gender		
	Men	67 (97.10%)
	Women	2 (2.90%)
Age (yr)		
	Mean (M)	40.33
	Standard Deviation (SD)	7.05
	Median (Me)	38.00
	Quartiles (Q1–Q3)	36.00–44.00
	Range (Min–Max)	29.00–59.00
Length of Service (yr)		
	Mean (M)	17.74
	Standard Deviation (SD)	6.96
	Median (Me)	16.00
	Quartiles (Q1–Q3)	12.00–21.00
	Range (Min–Max)	7.00–36.00
Place of Employment		
	Emergency Medical Services Team	66 (95.65%)
	Air Ambulance Service	1 (1.45%)
	Hospital Emergency Department	9 (10.47%)
	Emergency Call Centre	9 (10.47%)
	Reception Area	1 (1.16%)

3.2 CPR performance analysis

In our detailed analysis of CPR performance among paramedics, we evaluated the frequency and volume of ventilations alongside the depth and frequency of chest compressions. Our observations highlighted an average ventilation rate of 4.51 breaths per minute and an average ventilation volume of 0.36 litres. This finding, particularly the rate of 4.51 breaths per minute, raises important considerations regarding the alignment with current CPR guidelines, which recommend a balanced approach to ensure adequate oxygenation without compromising chest compression efficacy. The variability noted in our data underscores the need for ongoing evaluation and revising training protocols to emphasize the critical balance between ventilation frequency and chest compression techniques. Such adjustments will support paramedics in achieving the optimal impact of CPR, particularly in the use of bag and mask ventilation, a single technique we focused on for its prevalent application in emergency scenarios.

Upon analyzing chest compression parameters, we found a median rate of 118 compressions per minute, generally aligning with the recommended range of 100 to 120 compressions per minute. However, the observed variability, ranging from 87 to 146 compressions per minute and compression depths between 47 mm and 72 mm, underscores a broad spectrum of practice styles. These findings highlight the critical need

for uniform, standardized training to bolster adherence to CPR guidelines and ensure effective and consistent CPR delivery.

The variability in ventilation rates, especially the average rate of 4.51 breaths per minute, requires a closer examination against the backdrop of existing CPR guidelines, which typically recommend a more controlled rate to optimize patient outcomes. Our findings raise important questions about the current training and practice standards, suggesting that even seasoned paramedics may benefit from updated, evidence-based training sessions that address these discrepancies. Reviewing recent literature and CPR guideline updates will be essential in understanding these differences and adjusting training protocols accordingly. Given the variability in CPR performance, as detailed in Table 2, there is a clear imperative for revising training protocols to better align with current guidelines and emerging evidence. This necessity is underscored by the range of proficiency observed, advocating for an approach that tailors training to the nuanced needs of emergency responders.

3.3 Compliance with CPR techniques

Our analysis of the adherence to the established CPR compression-to-ventilation ratio of 30:2, as recommended by the European Resuscitation Council, revealed a concerning trend. Only a minority of paramedics were found to follow this critical guideline rigorously. This discrepancy, varying from minor to significant deviations, underscores a crucial gap in training and practice. Given the direct impact of the compression-to-ventilation ratio on patient survival, these findings highlight an urgent need for more focused and consistent CPR training. Ensuring paramedics adhere to this guideline is essential for improving CPR outcomes in real-life scenarios.

3.4 Analysis of ventilation volumes

The study's evaluation of ventilation volumes administered during CPR provided significant insights into the paramedics' performance. As demonstrated in Fig. 1, ventilation volume—the amount of air delivered to the patient's lungs with each breath—is critical for ensuring adequate oxygenation during resuscitation. Fig. 1 shows explicitly the data on ventilations performed, indicating that participants ventilated 1857 times during the study. Alarmingly, most of these ventilations (87.4%) were below the lower limit of the normal range. Only 372 breaths (23.89%) were performed within the normal volume range, while 124 breaths exceeded the optimal volume, highlighting a significant deviation from ideal practice.

This discrepancy in achieving appropriate ventilation volumes, as quantitatively shown in Fig. 1, underscores a potential gap in training or proficiency among paramedics in this vital aspect of CPR. The frequent deviation from the ideal ventilation volume suggests the need for enhanced training methods, incorporating more hands-on practice and real-time feedback. Such improvements in training could ensure that paramedics are better equipped to gauge and deliver the appropriate ventilation volumes during CPR, thus improving the overall effectiveness of their resuscitation efforts.

3.5 Incidence and distribution of errors in CPR

Our in-depth analysis of CPR techniques has shed light on critical errors within ventilation and chest compression practices among paramedics. A concerning proportion of participants deviated from established protocols, affecting both ventilation volumes and compression rates—critical factors in CPR's effectiveness and patient survival. Specifically, ventilation errors varied from under to over-ventilation, and compression issues included incorrect rates and depths. These findings point to gaps in training or adaptation to emergency scenarios, emphasizing the urgent need for enhanced, focused training. We can minimize these errors by integrating frequent refreshers, real-life scenario simulations and continuous skill evaluations, reinforcing the paramount importance of high-standard emergency care. Table 3's data compellingly argues for this strategic approach to training, aiming to rectify identified performance gaps and uphold high-quality patient care in critical situations.

3.6 Summary of cumulative errors

Our comprehensive analysis, detailed in Table 4, examined the cumulative errors in CPR techniques among paramedics, revealing a broad spectrum of proficiency. The table categorizes errors into ventilation and chest compression techniques, illustrating a significant variance in skill levels across the board. While some paramedics excel, closely adhering to CPR guidelines, others falter, showcasing a clear need for targeted training interventions. This variability emphasizes the need for individualized training approaches and consistent skill assessments to improve CPR performance. Tailoring training to address these identified gaps is crucial for ensuring paramedics can deliver high-standard emergency care, as evidenced by the patterns of errors outlined in Table 4.

4. Discussion

The study's exploration into the effectiveness of CPR techniques among paramedics reveals several critical insights. Paramount among these is the realization that high-quality chest compressions, as emphasized in current guidelines, are indeed central to achieving a return of spontaneous circulation (ROSC) [1]. Our data indicates that paramedics achieved an admirable average compression depth of 58.4 mm, closely aligning with the European Resuscitation Council's recommended range of 50 mm to 60 mm [14]. This accomplishment is noteworthy, as it mirrors the high efficacy of compressions, a crucial determinant in patient survival during SCA.

Integrating high-quality chest compressions within the broader framework of emergency medical response is critical. While our study highlights the proficiency in compression depth, it also sheds light on the need for a holistic approach that balances compressions with other aspects of CPR. This holistic approach is vital when paramedics are the first and sometimes the only responders. The ability to quickly assess a situation and perform effective CPR, including compressions and ventilations, can be the difference between life and death

TABLE 2. Detailed ventilation and chest compression parameters.

Parameter	n	Mean (M)	Standard Deviation (SD)	Median (Me)	Quartiles (Q1–Q3)	Range (Min–Max)	Shapiro-Wilk (S-W)	Significance (*p*)
Minute Ventilations (liters/min)	69	1.79	1.02	1.80	1.00–2.50	0.00–4.00	0.967	0.0680
Ventilation Rate (breaths/min)	69	4.51	1.77	5.00	3.00–6.00	0.00–7.00	0.879	<0.0001
Ventilation Volume (liters)	69	0.36	0.14	0.40	0.30–0.40	0.00–0.70	0.940	0.0020
Rate of Chest Compressions (compressions/min)	69	116.70	11.05	118.00	110.00–124.00	87.00–146.00	0.989	0.8020
Chest Compression Depth (mm)	69	58.48	5.75	58.00	54.00–62.00	47.00–72.00	0.986	0.6530

Notes: Q1–Q3: Lower and Upper Quartile; S-W: Shapiro-Wilk Normality Test Result.

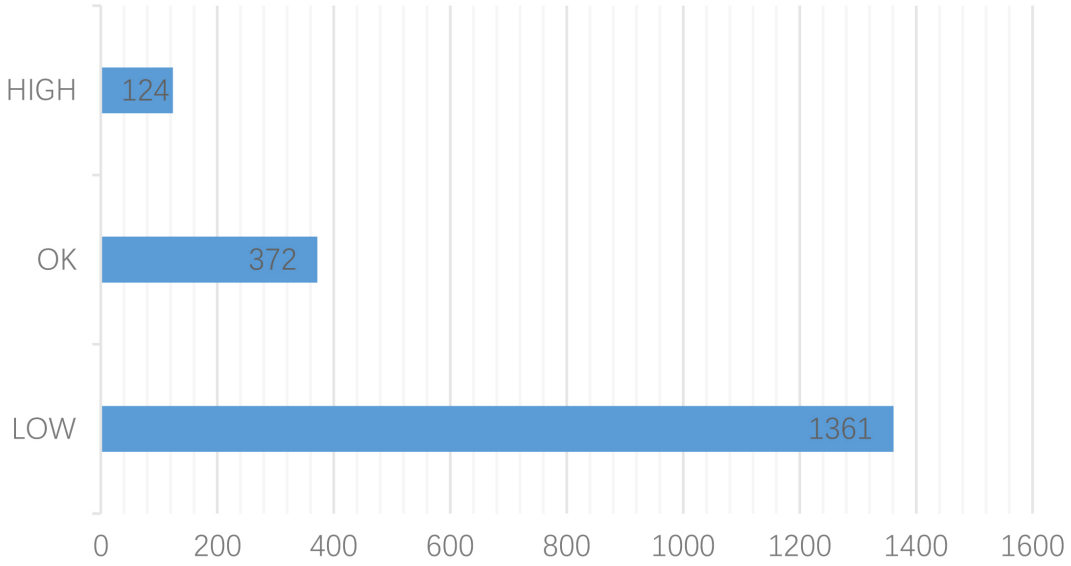

FIGURE 1. Distribution of ventilation volumes in CPR performance.

TABLE 3. Occurrence of errors in CPR techniques.

Error Type	No Compression Error	With Compression Error	Total
No Ventilation Error	1 (1.45%)	13 (18.84%)	14 (20.29%)
With Ventilation Error	0 (0.00%)	55 (79.71%)	55 (79.71%)
Total	1 (1.45%)	68 (98.55%)	69 (100.00%)

TABLE 4. Number of errors committed in CPR techniques.

No. of Ventilation Errors	No Compression Errors (0)	1 Compression Error	2 Compression Errors	3 Compression Errors	Total
0 Errors	1 (1.45%)	5 (7.25%)	6 (8.70%)	2 (2.90%)	14 (20.29%)
1 Error	0 (0.00%)	8 (11.59%)	16 (23.19%)	2 (2.90%)	26 (37.68%)
2 Errors	0 (0.00%)	4 (5.80%)	10 (14.49%)	7 (10.14%)	21 (30.43%)
3 Errors	0 (0.00%)	2 (2.90%)	1 (1.45%)	5 (7.25%)	8 (11.59%)
Total	1 (1.45%)	19 (27.54%)	33 (47.83%)	16 (23.19%)	69 (100.00%)

in many emergencies.

To enhance the clarity on our approach to ventilation, it is essential to note that we utilized a standard adult-size bag-valve-mask (BVM) for all ventilatory support during the CPR interventions in this study. This methodological detail, now explicitly mentioned in our methods section, aligns with widely accepted clinical practices and ensures the reliability of our ventilation-related findings. Comparative analyses with existing literature confirm that the achieved ventilation volumes are consistent with those recommended, underscoring the comparability of our results to broader resuscitation research.

However, the observed variation in compression depths, including excessive compression up to 72 mm, raises concerns about potential secondary injuries. This risk, underscored by studies including those by Heidi Hellevuo *et al.* [15], underscores the importance of pinpointing which participant group contributes to this variation to mitigate such risks effectively. Conversely, the infrequent underachievement in compression depth, albeit marginal, also warrants attention. These variations, although minimal, could significantly impact the outcomes of CPR, especially in prolonged resuscitation efforts where fatigue might further influence the depth of compressions.

After carefully considering the importance of incorporating pertinent research, we have thoroughly updated our reference list to more accurately represent the latest findings and methodologies in CPR effectiveness. Specifically, we have introduced newer studies that explore the essential relationship between compression depth and ventilation efficiency. This refresh of our citations enhances our analysis by offering a deeper insight into the individual contributions of each CPR component to patient outcomes, ensuring a more robust foundation of literature for our discussion.

Comparatively, our study's findings regarding the depth of compressions fare better than those observed in other professional groups, such as nurses, as documented in studies by Zubrzycki *et al.* [16] and Dudzinski *et al.* [17]. This difference could be attributed to the demographic variance, regularity of CPR performance and training intensity among paramedics. Nevertheless, the proficiency in achieving sufficient compression force, a challenge for non-medics, was commendably met by our study participants.

The disparity in compression depth observed between paramedics and other healthcare professionals, such as nurses, might reflect the varying frequencies and intensities of real-life CPR situations. Paramedics frequently face high-pressure scenarios requiring swift, decisive action, potentially refining their compression skills [18, 19]. However, it is critical to ensure that such comparisons are made within the context of similar methodologies or settings to ascertain the validity of these observations.

This observation suggests that the regularity and context of CPR training could be as important as the training content itself. Tailoring training to simulate real-life emergency scenarios enhances the effectiveness of CPR performed by all healthcare providers.

Our examination of ventilation techniques revealed a notable discrepancy in achieving optimal tidal volumes, highlighting an area for potential improvement in paramedic training. Recognizing this, we advocate for enhanced training modules focused specifically on ventilation strategies. Those strategies include not only the mechanical aspect of delivering breaths but also the critical judgment needed to adjust ventilation based on patient response. This adjustment could significantly improve the efficacy of CPR, ensuring that ventilation complements chest compressions effectively.

The role of fatigue in CPR performance must be considered. Long-duration resuscitations challenge the stamina and consistency of rescuers, potentially impacting the quality of chest compressions and ventilations [20]. This study's results suggest a need for research strategies to help paramedics maintain optimal performance over extended periods. These strategies include team-based approaches to CPR, allowing for periodic rotation to reduce individual fatigue and the use of mechanical CPR devices in prolonged resuscitation efforts.

The gap between mandatory training sessions for paramedics, particularly in CPR, has raised questions regarding the ongoing improvement and preservation of their skills. Based on our research, we suggest adopting a regular, organized method for continual learning. Shortening the period to yearly refreshment training might guarantee that paramedics stay proficient in the newest methods and in managing CPR's physical and emotional challenges. This adjustment could strengthen the overall quality of emergency services.

While chest compressions are pivotal, the role of effective ventilation cannot be understated, particularly in asphyxial cardiac arrests [21]. The study's revelation that nearly 90% of participants failed to achieve the lower tidal volume limit, with some not performing ventilation at all, is a significant concern. Adequate ventilation, integral to CPR success, requires maintaining airway patency and the skilful administration of replacement breaths [22, 23]. Our findings indicate proficiency in preventing air insufflation into the stomach, a standard error, yet highlight a need for improved ventilation techniques.

The issue of suboptimal ventilation techniques among paramedics raises questions about the current emphasis on CPR training programs [24]. While the focus on chest compressions is undoubtedly justified, this should not lead to the neglect of proper ventilation techniques. Effective ventilation is crucial for oxygenating the blood, particularly in prolonged cardiac arrest scenarios where oxygen reserves are quickly depleted [25]. Therefore, the need for balanced training that gives equal importance to both compressions and ventilations is evident.

The need for balanced training leads us to ponder the current training framework for paramedics in Poland. While the regimen effectively imparts compression techniques, it appears less successful in equipping paramedics with the nuanced skills required for optimal ventilation. The lack of clinical exposure during training is a notable gap. Periodic internships in intensive care units or operating theatres could allow paramedics to refine their ventilation skills under expert supervision [26, 27].

The five-year interval between obligatory in-service training sessions may be too extended, potentially impacting the retention and refinement of CPR skills. Literature suggests that more frequent, compulsory training sessions, ideally conducted every two years as recommended by leading health or-

ganizations like the American Heart Association, could be a viable strategy to enhance the overall quality of CPR paramedic's performance, ensuring maximum knowledge and skill retention [28, 29].

While paramedics demonstrate commendable proficiency in chest compressions, there is a clear avenue for enhancing ventilation techniques. Addressing this through intensified training and clinical exposure could significantly elevate the standard of CPR, ultimately positively impacting patient outcomes.

The importance of continuous feedback and assessment during CPR training cannot be overstated. Incorporating advanced training manikins and simulation technologies can provide paramedics with real-time feedback on their compression and ventilation techniques. This technology-enhanced approach can help identify and correct technique flaws in a safe learning environment, leading to more effective skill acquisition and retention. Investing in such training tools could be a strategic step towards elevating the overall quality and effectiveness of CPR provided by paramedics.

The study highlights the need for a more data-driven approach to continuous improvement in CPR training. Training programs can be regularly updated by systematically analyzing CPR performance data to address identified gaps. Additionally, leveraging advancements in digital health and data analytics can provide paramedics with personalized feedback and learning opportunities, further fine-tuning their skills in both chest compressions and ventilations [30, 31].

Another aspect warranting attention is the psychological readiness of paramedics for high-stress CPR scenarios. The mental and emotional preparedness of a rescuer can significantly influence the quality of CPR performed [32, 33]. Incorporating stress management and resilience training into the CPR curriculum could enhance paramedics' ability to remain calm and focused during emergencies, thereby improving the overall effectiveness of their resuscitation efforts.

In reflecting on the broader implications of this study, it is important to consider how the findings from the Lubelskie Voivodeship may resonate with or differ from CPR practices in other regions or against global standards. While there are universal guidelines for CPR, regional differences in training, resources and emergency response protocols can lead to variations in practice. For instance, the proficiency levels and challenges faced by paramedics in the Lubelskie Voivodeship might be similar to those in regions with comparable medical infrastructure and training programs. Conversely, areas with differing healthcare systems, resources, or cultural attitudes towards emergency response might exhibit distinct patterns in CPR performance. This comparison underscores the necessity of contextualizing CPR training and guidelines to fit local needs while adhering to global best practices. Furthermore, it highlights the potential value of international collaborative studies in comprehensively understanding CPR effectiveness and paramedic training needs globally.

We must consider several key factors to understand the underlying causes of errors in CPR techniques. First, the variability in training and educational backgrounds among paramedics can significantly influence their proficiency. Paramedics with more frequent and comprehensive training sessions, especially those that simulate real-life scenarios, are likely to perform more accurately under pressure. On the other hand, infrequent or less intensive training might lead to gaps in skill application, particularly in high-stress situations.

The psychological and physical state of the paramedics during emergencies plays a crucial role. Factors such as fatigue, stress and cognitive overload can adversely affect the precision of both ventilations and compressions. The ability to perform CPR correctly is a matter of technical skill, but mental resilience and physical stamina are also important, especially during prolonged resuscitation efforts.

Ergonomic factors and equipment familiarity are also crucial. The type and model of CPR manikins used during training compared to the equipment encountered in real-life situations can create discrepancies in technique application. Paramedics who regularly train with equipment that closely mimics real-life scenarios will likely be more adept at applying these skills in emergencies.

Lastly, the dynamics of the emergency environment, including team coordination and communication, significantly impact CPR performance. Effective teamwork and clear communication are essential for ensuring the optimal application of CPR techniques.

The insights gained from thorough analysis highlight the importance of a comprehensive approach to CPR training. Training should go beyond technical skills to include stress management, team dynamics and adaptability in emergencies. Simulation-based training and real-time feedback can support this all-encompassing development, equipping paramedics with the techniques, resilience and mental acuity required in critical circumstances. By enhancing training programs in this manner, we can close the gap between existing practices and the optimal standards of CPR execution, ultimately leading to better cardiac arrest outcomes.

These findings suggest a need for a multifaceted approach to CPR training for paramedics. Training programs should focus on the technical aspects of CPR and incorporate elements that address psychological resilience, stress management and familiarity with various emergency scenarios and equipment. Regular skill assessments and feedback mechanisms can help identify individual training needs and contribute to continuous skill improvement. By understanding and addressing these determinants, CPR training can be optimized to enhance the overall effectiveness and reliability of paramedics in emergencies.

5. Limitations

This pilot study, aimed at assessing the quality of CPR techniques among paramedics, offers significant insights but is accompanied by certain limitations that must be acknowledged. Firstly, the study's sample size, involving 69 paramedics from the Lubelskie Voivodeship in Poland, while adequate for a pilot study, limits the generalizability of the findings. This relatively small cohort means that the results may not fully represent the CPR performance of paramedics on a broader scale, which could vary across regions or countries with diverse medical practices and training standards.

Another limitation pertains to the training equipment and scenario replication. The study's use of specific equipment,

the Ambu Man manikins, and a uniform 6-minute duration for CPR exercises may not encapsulate the full spectrum of challenges and variabilities encountered in real-life emergency scenarios. In actual medical emergencies, paramedics often face unpredictable situations, including patient variability, environmental factors and prolonged resuscitation efforts, which this controlled study setting may need to replicate adequately.

Additionally, the study limited the diversity in training environments and scenarios. The homogeneous nature of the training setup could impact the applicability of our findings to a broader range of paramedic practices. Real-world emergencies are diverse and often require paramedics to adapt their techniques to various situations, a factor our study could only partially explore due to its specific training environment.

The regional specificity of the study also poses a limitation. Conducted within a specific area of Poland, the study's findings are influenced by the local context, which includes regional protocols, training standards and typical emergencies. Therefore, the results should be cautiously applied to other contexts, considering the regional variations in medical emergency response.

As a pilot study, this research primarily serves as a preliminary exploration into paramedics' CPR performance. It sets the foundation for future studies that can expand upon these initial findings with a more extensive, diverse and comprehensive approach. Future research can build on this study's insights, exploring a more comprehensive array of scenarios and including more extensive and varied participant groups to enhance the understanding of CPR effectiveness among emergency medical personnel.

While this study provides valuable information about CPR techniques and training among paramedics, the limitations outlined here highlight the need for further research and careful interpretation of the findings when considering their application beyond the specific context of this study.

6. Conclusions

This pilot study within the Lubelskie Voivodeship of Poland, involving 69 paramedics, has elucidated significant insights into CPR techniques, specifically highlighting strengths in chest compression depth within recommended guidelines. Despite this, the study uncovered areas necessitating focused improvement, particularly in ventilation techniques and adherence to compression-to-ventilation ratios. The observed variations in practice underline the critical need for enhanced, recurrent training programs tailored to real-life emergency scenarios. These programs should aim to refine technical skills and decision-making capabilities under stress, ensuring paramedics are well-equipped to deliver high-quality CPR. Future research is encouraged to explore the impacts of training enhancements on CPR effectiveness and paramedic performance in varied emergency contexts.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

ŁM—provided the main framework, identified and organized primary materials and collaborated in writing the manuscript. KN and AMAW—identified appropriate references and collaborated on the writing of the manuscript. KG—reviewed and contributed to drafting sections of the manuscript. KS and MA—collaborated on the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was conducted following ethical guidelines and approvals from the bioethics committee (KE-0254/284/2020) and the Lublin Regional Ambulance Service. These approvals ensured adherence to ethical standards in conducting research with human participants. Additionally, we obtained consent from all subjects to participate in the study, further ensuring the ethical integrity of our research process.

ACKNOWLEDGMENT

The authors would like to extend their appreciation to King Saud University for funding this work through the Researchers Supporting Project number (RSPD2024R649), King Saud University, Riyadh, Saudi Arabia.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Gräsner J, Wnent J, Herlitz J, Perkins GD, Lefering R, Tjelmeland I, *et al*. Survival after out-of-hospital cardiac arrest in Europe—results of the EuReCa TWO study. Resuscitation. 2020; 148: 218–226.

[2] Malik A, Gewarges M, Pezzutti O, Allan KS, Samman A, Akioyamen LE, *et al*. Association between sex and survival after non-traumatic out of hospital cardiac arrest: a systematic review and meta-analysis. Resuscitation. 2022; 179: 172–182.

[3] Allan KS, Mammarella B, Visanji M, Moglica E, Sadeghlo N, O'Neil E, *et al*. Methods to teach schoolchildren how to perform and retain cardiopulmonary resuscitation (CPR) skills: a systematic review and meta-analysis. Resuscitation Plus. 2023; 15: 100439.

[4] Kuang J, Yang J, Wang Q, Yu C, Li Y, Fan R. A preoperative mortality risk assessment model for Stanford type A acute aortic dissection. BMC Cardiovascular Disorders. 2020; 20: 508.

[5] Considine J, Gazmuri RJ, Perkins GD, Kudenchuk PJ, Olasveengen TM, Vaillancourt C, *et al*. Chest compression components (rate, depth, chest wall recoil and leaning): a scoping review. Resuscitation. 2020; 146: 188–202.

[6] Semeraro F, Greif R, Böttiger BW, Burkart R, Cimpoesu D, Georgiou M, *et al*. European resuscitation council guidelines 2021: systems saving lives. Resuscitation. 2021; 161: 80–97.

[7] Lott C, Truhlář A, Alfonzo A, Barelli A, González-Salvado V, Hinkelbein

J, *et al*. European resuscitation council guidelines 2021: cardiac arrest in special circumstances. Resuscitation. 2021; 161: 152–219.
[8] Gässler H, Kurka L, Rauch S, Seewald S, Kulla M, Fischer M. Mechanical chest compression devices under special circumstances. Resuscitation. 2022; 179: 183–188.
[9] Gianni A, Botteri M, Stirparo G, Mattesi G, Zorzi A, Villa GF. The impact of the Italian law mandating an automatic external defibrillator in all sports venues on sudden cardiac arrest resuscitation rates. European Journal of Preventive Cardiology. 2024; 31: e16–e18.
[10] Dewi AK, Putri FF, Hakim MT, Putri RS, Santosa CR, Jannata AM, *et al*. Literature review cardiopulmonary resuscitation management for sudden cardiac arrest on field sport activity. Surabaya Physical Medicine and Rehabilitation Journal. 2023; 5: 117–129.
[11] Danış F, Kudu E. The evolution of cardiopulmonary resuscitation: global productivity and publication trends. The American Journal of Emergency Medicine. 2022; 54: 151–164.
[12] Schnaubelt S, Garg R, Atiq H, Baig N, Bernardino M, Bigham B, *et al*. Cardiopulmonary resuscitation in low-resource settings: a statement by the international liaison committee on resuscitation, supported by the AFEM, EUSEM, IFEM, and IFRC. The Lancet Global Health. 2023; 11: e1444–e1453.
[13] Bednarz K, Goniewicz K, Al-Wathinani AM, Goniewicz M. Emergency medicine perspectives: the importance of bystanders and their impact on on-site resuscitation measures and immediate outcomes of out-of-hospital cardiac arrest. Journal of Clinical Medicine. 2023; 12: 6815.
[14] Considine J, Gazmuri RJ, Perkins GD, Kudenchuk PJ, Olasveengen TM, Vaillancourt C, *et al*. Chest compression components (rate, depth, chest wall recoil and leaning): a scoping review. Resuscitation. 2020; 146: 188–202.
[15] Hellevuo H, Sainio M, Nevalainen R, Huhtala H, Olkkola KT, Tenhunen J, *et al*. Deeper chest compression—more complications for cardiac arrest patients? Resuscitation. 2013; 84: 760–765.
[16] Zubrzycki W, Przyjemczak J, Świeczko-Żurek B. The effectiveness of basic resuscitation activities carried out by combat paramedics of the police, as exemplified by polish counterterrorist units. Internal Security. 2021; 13: 285–298.
[17] Dudzinski DM. Pulmonary embolism-related cardiac arrest. PERT Consortium Handbook of Pulmonary Embolism. 2023; 45: 1–9.
[18] ALQarni BD, Qarni AL, Ayed F, Rashidi AL, Mueallath A, Mutairi AL. The effects and challenges faced by health practitioners in dealing with emergency cases. International Journal. 2022; 10: 102–109.
[19] Al-Jaafreh A, Saifan AR, Mosleh SM, Al-Yateem N, Al-Momani MM. Experience of health professionals in caring for patients with chest trauma. Dimensions of Critical Care Nursing. 2023; 42: 153–162.
[20] Hinkelbein J, Kerkhoff S, Adler C, Ahlbäck A, Braunecker S, Burgard D, *et al*. Cardiopulmonary resuscitation (CPR) during spaceflight—a guideline for CPR in microgravity from the German Society of Aerospace Medicine (DGLRM) and the European Society of Aerospace Medicine Space Medicine Group (ESAM-SMG). Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2020; 28: 108.
[21] Kong Y, Guo W. Respiratory support strategy for sudden cardiac death. Sudden Death. 2021; 23: 217–240.
[22] Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, *et al*. Part 3: adult basic and advanced life support: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2020; 142: S366–468.
[23] Palisch AC. Airway management of the cardiac arrest victim. Emergency Medicine Clinics. 2023; 41: 543–558.
[24] Davis DP, Peay J, Sise MJ, Kennedy F, Simon F, Tominaga G, *et al*. Prehospital airway and ventilation management: a trauma score and injury severity score-based analysis. Journal of Trauma: Injury, Infection & Critical Care. 2010; 69: 294–301.
[25] Kopra J, Litonius E, Pekkarinen PT, Laitinen M, Heinonen JA, Fontanelli L, *et al*. Ventilation during continuous compressions or at 30:2 compression-to-ventilation ratio results in similar arterial oxygen and carbon dioxide levels in an experimental model of prolonged cardiac arrest. Intensive Care Medicine Experimental. 2023; 11: 1–4.
[26] Dronamraju VA, Chilamakuru R, Gara HK, Vanamali DR, Kasibhotla VC. Assessment of knowledge, attitude, and practices of basic life support among interns and residents in a tertiary care hospital. European Journal of Cardiovascular Medicine. 2023; 13: 1248–1260.
[27] Mariano S. Preparing paramedic graduates for independent practice: an assessment of the effectiveness of a paramedicine degree from a university in KwaZulu-Natal [Doctoral thesis]. University of KwaZulu-Natal, South Africa. 2022.
[28] Merchant RM, Becker LB, Brooks SC, Chan PS, Del Rios M, McBride ME, *et al*. The American heart association emergency cardiovascular care 2030 impact goals and call to action to improve cardiac arrest outcomes: a scientific statement from the American heart association. Circulation. 2024; 149: e914–e933.
[29] Sumera K, Ilczak T, Bakkerud M, Lane JD, Pallas J, Martorell SO, *et al*. CPR quality officer role to improve CPR quality: a multi-centred international simulation randomized control trial. Resuscitation Plus. 2024; 17: 100537.
[30] Goniewicz K, Khorram-Manesh A, Burkle FM, Hertelendy AJ, Goniewicz M. The European Union's post-pandemic strategies for public health, economic recovery, and social resilience. Global Transitions. 2023; 5: 201–209.
[31] Khorram-Manesh A, Gray L, Goniewicz K, Cocco A, Ranse J, Phattharapornjaroen P, *et al*. Care in emergencies and disasters: can it be person-centered? Patient Education and Counseling. 2024; 118: 108046.
[32] Martin-Conty JL, Martin-Rodríguez F, Criado-Álvarez JJ, Romo Barrientos C, Maestre-Miquel C, Viñuela A, *et al.* Do rescuers' physiological responses and anxiety influence quality resuscitation under extreme temperatures? International Journal of Environmental Research and Public Health. 2020; 17: 4241.
[33] Silverplats J, Strömsöe A, Äng B, Södersved Källestedt ML. Attitudes towards cardiopulmonary resuscitation situations and associations with potential influencing factors—a survey among in-hospital healthcare professionals. PLOS ONE. 2022; 17: e0271686.

How to cite this article: Łukasz Maciejewski, Katarzyna Naylor, Konrad Szast, Ahmed M. Al-Wathinani, Mohammed Aljuaid, Krzysztof Goniewicz. Enhancing EMS readiness: a pilot evaluation of CPR proficiency and training dynamics among paramedics in Poland. Signa Vitae. 2024. doi: 10.22514/sv.2024.063.