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Carlos J.A. Silva, Paramedic — *Guimarães Fire Department; International Prehospital Medicine Institute; Sociedade Portuguesa de Emergência Pré-Hospitalar (Portuguese PreHospital Emergency Society):* Guimarães, Portugal

Hezedean Smith, DM, CFO, FACPE — *Founder / Chief Executive Officer, Global Emergency Services Consulting Group, LLC; Adjunct Faculty, Embry Riddle Aeronautical University:* Orlando, FL, USA

Larry M. Starr, PhD — *Director of Applied Research, Lee Iacocca Institute for Global Leadership, Lehigh University; Adjunct Assistant Professor of Pharmacy Systems Science, Department of Medical Education, Geisinger Commonwealth School of Medicine; Managing Director, Systems Wisdom, LLC:* Wynnewood, PA, USA

Robert E. Suter, DO, MHA — *Professor, University of Texas Southwestern Medical Center; Reserve Brigadier General, US Army:* Dallas, TX, USA

Simon Taxel, MPH, NRP — *Crew Chief, City of Pittsburgh Bureau of EMS; Lecturer, School of Public Health, University of Pittsburgh:* Pittsburgh, PA, USA

Stephen E. Taylor, Paramedic, PhD, FAEMS — *EMS Specialist, East Carolina University; Pitt County EMS:* Washington, NC, USA

Sean M Teed, CCP, MEd(c) — *Paramedic Educator, Nova Scotia Health:* Halifax, NS, Canada

John Todaro, BA, NRP, RN, TNS — *Director, Eagle Emergency Education Consultants; Associate Advisor, Cambridge Consulting Group:* Land O Lakes, FL, USA

Tara Tucker, MS, EMT-P, CP-C — *Lead Community Paramedic, Cape Fear Valley Hospital:* Madison, NC, USA

Robert S. Wales, BS, NRP, ALM — *Medical Education Program Manager, Medtronic, Inc:* Plano, TX, USA

James J Warin, MPA, NRP, CHSE, CHSOS — *Simulation Operations Specialist, Simulation Center, Valley Health System; Paramedic, Mobile Intensive Care Unit, Hackensack Meridian Health University Medical Center; EMT Instructor, Bergen County Technical Schools:* Hopatcong, NJ, USA

Jonathan D. Washko, MBA, FACPE, NRP, AEMD — *Assistant Vice President, Center for EMS, Northwell Health:* Northport, NY, USA

Siegfried Weinert, NKV, EMD, SFK — *Cross Border EMS Management, Notruf Niederösterreich (Emergency Call Lower Austria); NKV, LBA-EH, LBA-San, PAS, Austrian Red Cross:* Wiener Neudorf, Lower Austria, Austria

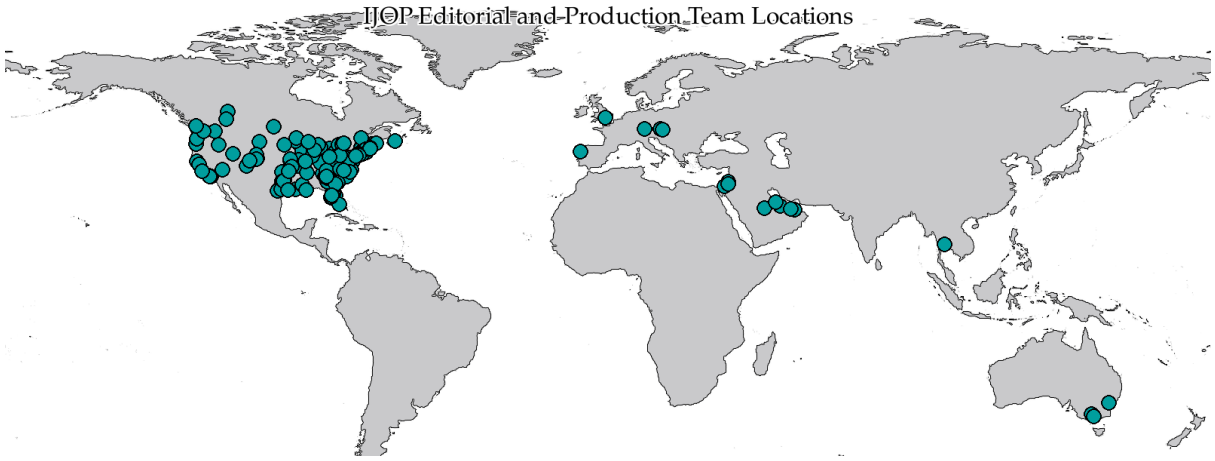
Katherine H. West, RN, BSN, MSEd — *Consultant, Infection Control Emerging Concepts, LLC:* Palm Harbor, FL, USA

Marquita F. Whisonant, EdD(c), MS, CNS, NRP — *Assistant Director, Center for Trauma & Critical Care Education, Virginia Commonwealth University; Assistant Professor, Reynolds Community College:* Henrico, VA, USA

Joseph Williams, IV — *National Director, Healthcare IT Products, Quality Outcomes Research Analytics, American Heart Association (AHA):* Detroit, MI, USA

Matthew M. Womble, EMT-P(Ret), MHA — *Regional Chief Operating Officer, American Red Cross (ARC):* Edenton, NC, USA

Joshua A. Worth Sr., MPA, NRP, CEMSO — *Director of Clinical Services, AmeriPro Health; Program Director, Public Safety Institute, Community College of Allegheny County:* Pittsburgh, PA, USA



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RESEARCH REPORTS

THE INFLUENCE OF OPERATIONAL EXPOSURE ON SCENE TIME: AGENCY CALL VOLUME AND THE COMPRESSION OF ON-SCENE TIME VARIABILITY IN EMERGENCY MEDICAL SERVICES

Jennifer Ziemke, PhD, EMT-P*[1,2]

Author Affiliations: 1. Political Science, John Carroll University, University Heights, OH, USA; 2. Lifecare Ambulance, Elyria, OH, USA.

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**Corresponding Author:* jziemke@jcu.edu

ABSTRACT

A limited number of emergency medical services (EMS) agencies respond to a disproportionate share of all 911-initiated calls in the United States. This study tests the hypothesis that responding units operating within high-volume service areas exhibit shorter and more consistent on-scene times for most call types than units serving lower-volume areas.

This study uses patient care report data generated from EMS providers whose agencies then contribute these reports to the national repository, the National Emergency Medical Services Information System (NEMSIS). The repository publishes data on a yearly basis. A random sample was drawn from approximately 262.7 million records between 2017 and 2023 to create a dataset of over 232,000 records for hypothesis testing. The data reveal a profound inequality of workload in that a relatively small number of agencies from across the country are responsible for handling the vast majority of all 911 calls represented in the sample. Of 7,536 agencies appearing in the nationwide sample, only 75 agencies (~1%) handle 30% of all calls, which is nearly twice the volume of the 6000 least busy agencies put together. Exceptionally busy agencies post faster scene times on average, and these effects survive multivariate analysis. Busy agencies are also less likely to exhibit extreme delays in scene times – keeping their scene times within a narrow and predictable range. No agency in the top 20% busiest by call volume had an agency-level median scene time exceeding 26.7 minutes. Connecting deidentified agency-level codes to each report further permits consideration of high call volume as a possible proxy for experience at the agency level.

INTRODUCTION

A limited number of extremely busy EMS agencies account for a substantial portion of 911 calls in the United States. Because a small number of agencies account for the majority of EMS activations, understanding how these high-volume agencies differ in performance is critical for understanding the overall context and constraints of providing emergency medical services in environments that are often resource constrained, and where the needs of the population they serve can easily outstrip their capacity to respond.

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Though some agencies respond to both 911 emergencies and non-urgent patient transfers, this study explicitly removes all Interfacility Transfers (IFTs), scheduled transports, and other administrative type calls from the analysis to focus the paper on the provision of emergency medical services for those that call for help.

This study tests the hypothesis that responding units from high–call-volume agencies post, on average, shorter median on-scene times than units operating in lower-volume areas. Previous work on organizational learning mechanisms highlights the role of call volume in other empirical studies of EMS performance (Lloyd et al., 2025). Agency-level analyses suggest that call volume can serve as a meaningful proxy for organizational learning and performance (Silver et al., 2024). Related examples demonstrate how agency-level learning behavior increases the likelihood of positive patient outcomes, like successful intubation (Dyson et al., 2017). Previous research has also examined the important role that pre-hospital on-scene time plays in analysis of patient care (Dong et al., 2022; Hsia, 2018; Ito et al., 2022; Medrano et al., 2023; Ueno et al., 2024).

To reiterate, this study tests the hypothesis that high–call-volume agencies post, on average, shorter median on-scene times when compared with units operating in areas of lower call volume. But why might that be the case? Agencies that post higher than median call volume are said to have more "operational exposure" because more calls mean more interaction with patients. Such repetition helps form the basis for pattern recognition, enabling responders to more quickly ascertain what needs to happen in response to each unique, individual call. Call volume at the agency level might serve as a reflection of an underlying hidden variable, "the level of experience of the responding unit." However, a more holistic measure of experience would include: number of years each responder has working in the field, their health care experience in other service areas or venues (inside or outside of the hospital), level of education, additional certifications, and more. Both for the purposes of preserving patient privacy and overall feasibility, however, these data are not available.

In many service areas, EMS faces chronic staffing shortages. Though a first responder may be working with one patient at a time, these providers remain acutely aware that their behavior on-scene impacts not only this patient but the next person who might need help as well. Field experience suggests responders routinely listen to the radio traffic for the whole service area both from their own local dispatchers, the county 911 trunk system, and other channels from corresponding fire and police departments specifically in order to gauge the overall current level of call volume. In this way, responders learn to place each call in the context of everything else going on at the time in their service area.

However, it is important to note that posting shorter scene times is not inherently preferred or considered "better" or "worse" for patient care. Nothing construed here is meant to imply that the "best" services merely act as a quick taxi service to the hospital. Far from it. In fact, responders recognize that certain calls require longer scene times in order to provide the patient with proper care, and they stay on scene as long as it takes to provide lifesaving services. On the other hand, a unit posting excessively long scene times, especially on low-acuity calls, on a consistent basis may reduce the system's ability to preserve response capacity for subsequent calls. In short, scene time is important because of the greater operational and strategic context within which EMS operates.

Providers must not only think of the individual patient before them but also of their promise to preserve emergency-response capacity for the populations they serve.

While median scene times might be faster for these high-volume units, the nature of scene response is expected to also be conditional on the dispatched call type. In particular, the analysis tests whether dispatched call types independently experience extended scene times: Air Medical, Traffic (MVA), Automated Crash Notification, Fire, Standby, Industrial Accident, or Hazmat Incident. Finally, calls dispatched as Cardiac Arrests are ceteris paribus expected to have longer scene times regardless of agency call volume.

DATA & SAMPLING

To test the hypothesis, data were drawn from the National Emergency Medical Services Information System (NEMSIS) data repository for each year between 2017–2023. Taken together, the full dataset comprises some 262.7 million patient records routed to EMS from the 911 system, drawn from data contributions by individual first-responding agencies from all across the United States. The NEMSIS dataset consists of a series of individual patient care reports generated by first responders after each patient contact in the field.

The NEMSIS team has taken careful and extensive steps to ensure patient privacy has been maintained by stripping any names, addresses, or other potentially identifying information from the dataset, including a complete masking of all location-based data. It is important that these data remain anonymous because every element of information related to dispatched call type, patient medical conditions, allergies, weights, symptoms, vitals, medications delivered, cardiac rhythms, IV/IO/Intubation procedures initiated (and much more) is recorded and made available in the dataset to researchers upon request. Variables have also been created to mark the geographic region where the incident took place (East, West, South, Great Lakes and Western Plains) as well as measures of relative urbanicity (Urban, Suburban, Rural and Wilderness). However, geographic data even at the state level has been deleted from the database to maintain patient privacy. Agency-level data are maintained separately by the NEMSIS Technical Assistance Center and are available only upon special request. A separate file was obtained linking each patient care report key (pcrkey) to an agency through an anonymized agency identifier, which was later merged into each run-level observation.

From a methodological perspective, it is important to note that any analysis of even the complete dataset of some 262.7 million events routed to the EMS system between 2017 and 2023 would not constitute the complete "universe" of all patient care reports in the United States, because individual agencies decide for themselves whether to submit their repositories and some elect not to do so. Nevertheless, every year a growing number of agencies submit their data to the database. Each year's annual data release reflects increased participation in the effort.

Because each annual NEMSIS release consists of multiple large, interrelated tables totaling hundreds of millions of records, conventional random sampling—which requires full ingestion of the dataset prior to sampling—is computationally prohibitive. To address this constraint, reservoir sampling - a single-pass probabilistic sampling algorithm that produces an unbiased random sample without requiring full dataset loading into memory – was employed. The approach was implemented using a dedicated RStudio server

instance deployed on DigitalOcean cloud infrastructure, enabling efficient streaming of records directly, which allowed sampling to occur during file ingestion rather than after the data is fully loaded. As records are read sequentially, the algorithm probabilistically updates the sample, ensuring that each observation has an equal probability of inclusion.

An agency-level dataset was also generated alongside the "run-level" dataset (where each individual report constitutes a unit of analysis). The agency-level data were created by counting the number of sampled incidents attributed to each agency. Agencies were rank-ordered by call volume, and percentile-based thresholds were used to identify the busiest 1%, 5%, 10%, 15%, 20%, and 25% of agencies and then subsequently merged back into the run-level data using the deidentified agency codes.

MODEL

The dependent variable is scene time in minutes, derived from the difference between two raw NEMSIS timestamps on each record: the precise local time (hours:minutes:seconds) the unit arrives on scene until the time the unit leaves for the destination. Extensive data hygiene procedures were applied, including removal of negative values, correction of 24-hour rollover errors, and conversion of clearly implausible administrative values (e.g., scene times exceeding multiple days) to missing values.

The primary independent variable, High-Volume Agency, is a binary indicator identifying agencies in the top 20% of total operational call volume within the study sample. Call volume is used here as a proxy for operational exposure. Sensitivity analysis led to the creation of several sequential models which tested to see if parameter estimates remained robust to changes in the "cut point" from 5%, to 10%, 15%, 20%, 25% and 30%.

As previously discussed, Structural Delay Present is set equal to one when the dispatched call type is: Air Medical, Traffic (MVA), Automated Crash Notification, Fire, Standby, Industrial Accident, or Hazmat Incident. In these cases, the source of delay on scene is likely out of EMS control (e.g. dependent on extrication of the patient by Fire, waiting on further dispatch orders, etc.). In addition, the model controls for the impact of Cardiac Arrest calls on scene times, given the expectation that units will stay on scene longer to provide life-saving care.

ALS Case Share (Agency) is defined as the proportion of an agency's total responses designated as advanced life support (ALS). Initial Acuity is a categorical variable where providers select level of initial patient acuity by color where green = low acuity, yellow = intermediate acuity, and red = high acuity. Black refers to patients who are deceased in the field. The reference category for this variable is "Not Recorded." Other controls included: COVID Era, which is a variable set equal to one for calls occurring during the WHO-declared COVID-19 public health emergency (March 11, 2020–May 11, 2023), and zero otherwise; Overnight Call, which is set equal to one for calls dispatched between 0000 and 0730 local time; Weekend Call, which is set equal to one for calls occurring on weekends; Child Patient, set equal to one if the patient was under 18 years of age and zero otherwise; and Urban Location, set equal to one for urban service areas and zero for suburban, rural, or wilderness settings.

The reduction in sample observations from 236,963 to 232,630 occurred when 91 observations were dropped due to missing scene time data and after the exclusion of 4248 obser-

vations missing urbanicity data classification. Six observations missed both parameters and were also dropped. Before turning to a formal test of the complete model, an initial exploratory analysis of the dataset is conducted.

INEQUALITY IN CALL VOLUME BY AGENCY

Examining the agency-level data displayed in Table 1, a highly unequal distribution of call volume across agencies emerges. The distribution is extremely right-skewed (Figure 1). The skew is also reflected by a measure of inequality typically used to discuss class-based inequity at the country-level. The Gini coefficient for this sample was calculated to be 0.798 on a scale from 0-1 where 0 represents perfect equality and 1 represents the most extreme inequality possible (for e.g. a society with 1 billionaire amongst an impoverished population). This means that the vast majority of calls in the sample are handled by a small percent of agencies. The top 20% of busiest agencies handle 83.5% of all calls in the sample. In fact, out of a total of 7,536 sampled agencies, 30% of all calls are handled by only 1% of agencies (75 agencies). This means that the top 1% of agencies (by call volume) handle nearly twice the total volume handled by 6000 "low volume" agencies put together.

Agency Group (Cumulative)	Agencies (*n*)	% of Agencies	Calls (*n*)	% of All Calls
Top 1% busiest agencies	75	1.0%	72,061	30.4%
Top 5% busiest agencies (includes Top 1%)	376	5.0%	137,526	58.0%
Top 20% busiest agencies (includes Top 5%)	1,507	20.0%	197,836	83.5%
Bottom 80% of agencies	6,029	80.0%	39,098	16.5%
Total	7,536	100%	236,963	100%

Table 1. Distribution of total call volume by agency.

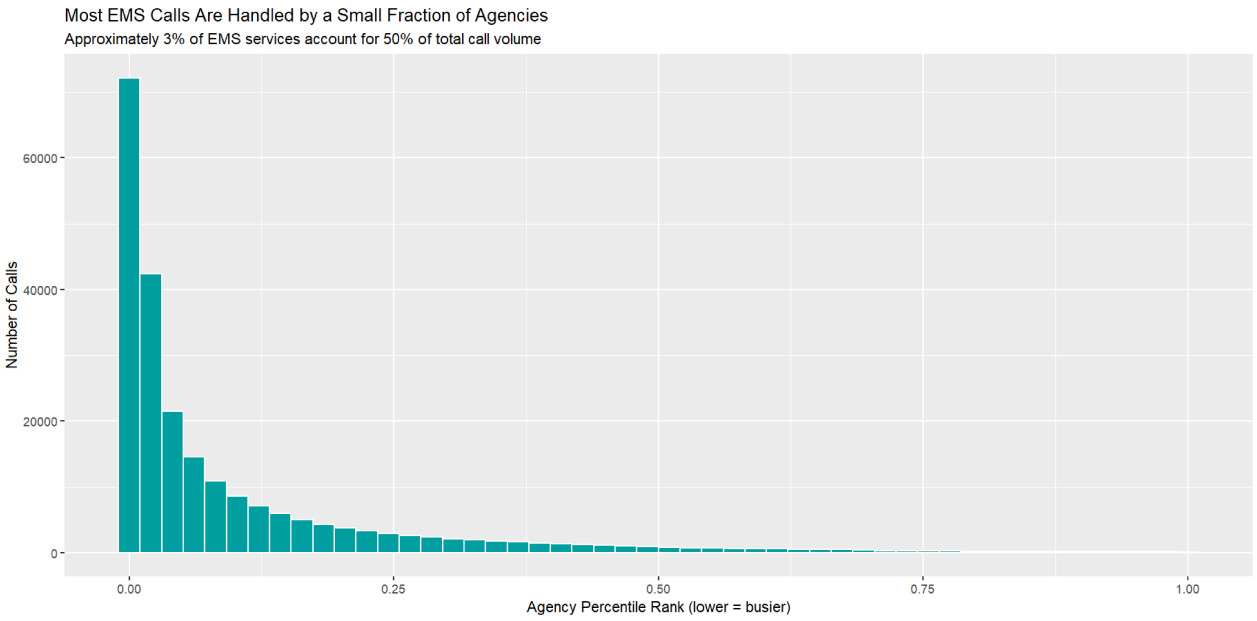


Figure 1. Distribution of calls by masked agency ID.

Figure 2 presents empirical cumulative distribution functions of scene times, stratified by agency call volume. At nearly every time threshold, a greater share of high-volume agency calls has cleared the scene relative to low-volume agencies. These differences persist even after conditioning on urban geography, suggesting that agency volume captures organizational characteristics beyond location alone. However, it should also be noted that agencies across all levels of operational exposure are capable of posting very fast median scene times, as the left tail of the distribution reveals. High efficiency is achievable across a wide range of operational contexts regardless of operational exposure or call volume rates.

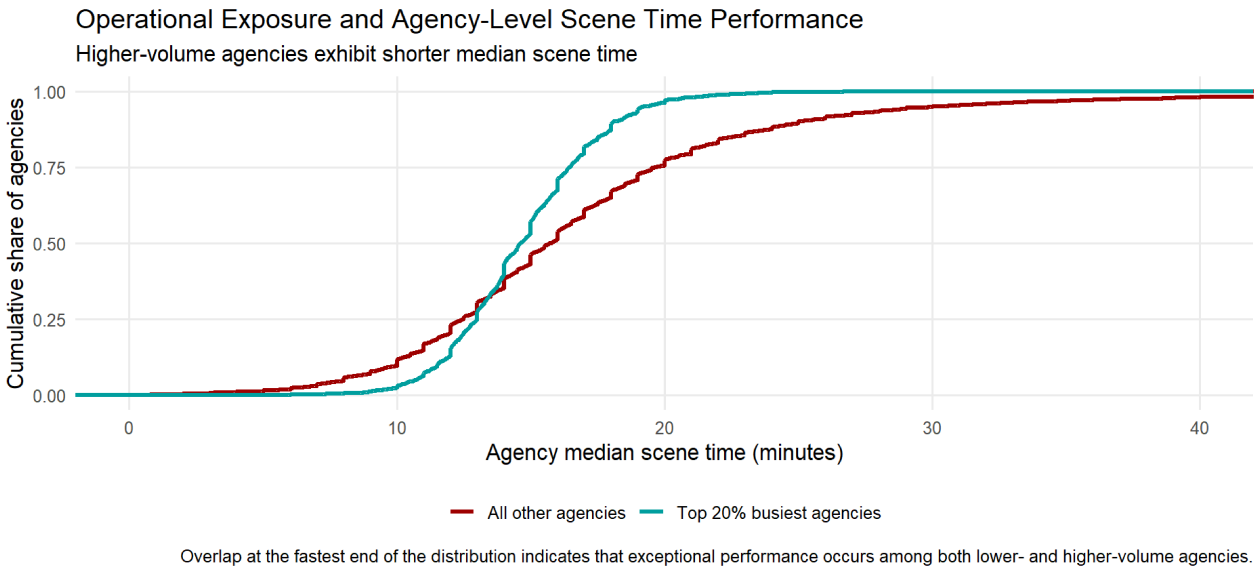


Figure 2. Cumulative distribution of scene-time duration by agency volume.

Perhaps most striking is a direct comparison of scene times distributions for low and high-volume agencies as evidenced by Figure 3. The right side of Figure 3 shows that high-volume agencies post much more consistent scene times. In fact, the top 20% of busiest agencies (who alone are responsible for responding to 197,836 runs, or 83.5% of the total runs in the sample) post zero median scene times above 26.7 minutes. The lack of distribution at the "tails" is striking compared with the wide distribution exhibited on the left by the low-volume responders, who seem just as likely to post short scene times as their busier counterparts. The main difference appears to be in the tails of the distribution: the fact that they do also post a healthy sample of extremely long scene times.

Bootstrapped inference provides formal confirmation of visual patterns. The difference in the 95th percentile of agency median scene time between the top 20% of agencies and all others was approximately 10–12 minutes (95% CI: 12.0 to 9.5 minutes; $p < 0.001$).

Differences became even more pronounced at more extreme thresholds. In exceedance models, agencies with the top 20% of call volume had approximately 99% lower odds of exhibiting median scene times over 25 minutes (OR = 0.01; 95% CI: 0.002–0.035). Together, these results indicate not only compression of the upper tail but near-complete absence of extreme agency-level median scene times among high-volume agencies.

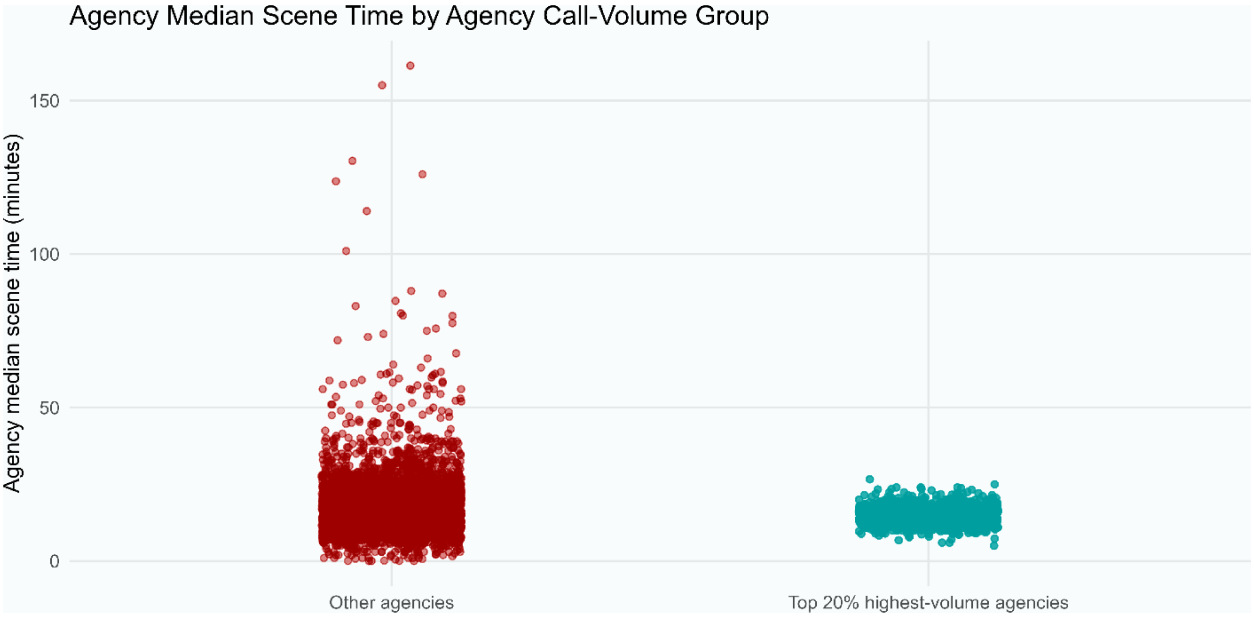


Figure 3. Comparison of scene-time distributions: High volume vs. low volume agencies.

To formally test whether agency call volume exerts an independent influence on scene time duration, multivariate regression models are used that account for call characteristics, clinical context, timing, and structural sources of delay.

MODEL ESTIMATION

Models were estimated using ordinary least squares with HC3 heteroskedasticity-robust standard errors to account for non-constant variance (Figure 4).

Let i index EMS runs and j index agencies.

$$\begin{aligned}\text{Scene Time}_{ij} = \beta_0 \\ + \beta_1\ \text{High–Volume Agency}_{ij} \\ + \beta_2\ \text{ALS Case Share}_{ij} \\ + \beta_3\ \text{Urban}_{ij} \\ + \beta_4\ \text{Overnight}_{ij} \\ + \beta_5\ \text{Weekend}_{ij} \\ + \beta_6\ \text{Child}_{ij} \\ + \beta_7\ \text{Structural Delay}_{ij} \\ + \beta_8\ \text{COVID Era}_{ij} \\ + \beta_9\ \text{Cardiac Arrest}_{ij} \\ + \beta_{10}\ \text{Initial Acuity}_{ij} + \varepsilon_{ij}\end{aligned}$$

Figure 4. Model specification.

DISCUSSION

Model estimates for the control variables presented in Table 2 are considered first. Whereas the analysis presented earlier indicated differences of approximately 11 minutes between low- and high-volume agencies at the upper end of the agency median scene-time distribution, these were bivariate relationships whose variation could potentially be due to other factors and rival explanations. Such variables are included to test whether competing explanations better explain the variation in scene time, and to see if any independent effect of agency volume on scene times survives even after controlling for several other variables.

As expected, both structural calls and cardiac arrest calls are associated with substantially longer scene times, with effects emerging that are both substantively large and statistically significant. Structural delay type calls are on average 2.7 minutes longer

Dependent Variable: Scene Time (minutes)	Estimate
High-Volume Agency (Top 20%)	0.600***(0.073)
Urban (Urban = 1)	-0.486***(0.076)
ALS Case Share (Agency)	1.602***(0.098)
Overnight Call (= 1 if dispatch time is between 0000 and 0730 local)	0.0658 (0.059)
Weekend Response (Weekend Response = 1)	0.221***(0.052)
Child Patient (= 1 if <18 years)	0.773***(0.099)
Structural Delay Present (= 1 if dispatched call type = Air Medical, Traffic Incident, Automated Crash Notification, Fire, Standby, Industrial Accident, or Hazmat)	2.695***(0.159)
COVID Era (= 1, if date between official CDC emergency dates 03/11/20-5/11/2023)	0.665***(0.045)
Cardiac Arrest (= 1 for this dispatched call type)	6.057***(0.336)
Measures of Initial Patient Acuity (Green/Yellow/Red/Black)	
Low acuity (Green)	-0.592***(0.064)
Intermediate acuity (Yellow)	0.810*** (0.071)
High acuity (Red)	1.216*** (0.137)
Deceased (Black)	12.278***(1.173)
Constant	18.021***(0.138)

Table 2. Explaining the variation in scene time duration.
*Note: Negative estimates indicate faster on-scene times. *** p<0.001*
Model: OLS, with HC3 heteroskedasticity-robust standard errors in parentheses.
Acuity Reference Category is "Not Recorded".
Observations: 232,630 | R^2: 0.0206 | Adjusted R^2: 0.0206

than other calls, holding every other variable constant (p<0.001). Cardiac arrest calls are associated with scene times just over six minutes longer than non-cardiac arrest calls (p<0.001). In addition, scene time length is partly a function of whether or not the event took place during the COVID-19 public health emergency. During the COVID period, calls had longer scene times when compared with the non-COVID era, by approximately 40 seconds (b = 0.665, p<0.001). Scene times are also 13 seconds longer on average during the weekend than during the weekday (b = 0.221, p<0.001). Ceteris paribus, responders from urban areas post shorter scene times by 29 seconds on average (b = -0.486, p<0.001). Finally, ceteris paribus, posted scene times were shorter when the patient was a child under the age of 18, when compared with adults over 18, by 46 seconds on average (b = -0.773, p<0.001). There was no statistically significant impact of time-of-day (night vs day) on scene times.

To what extent does initial acuity level help explain scene times? When compared with the reference category of Not Recorded, low-acuity cases are associated with scene times approximately 36 seconds shorter (b = 0.592, p < 0.001). Scene times are approximately 49 seconds longer for cases marked yellow (intermediate acuity; b = 0.810, p < 0.001), and 73 seconds longer for cases marked red (high acuity; b = 1.216, p < 0.001). Most striking is the finding for patients marked deceased: these calls are associated with an additional 12.278 minutes on scene compared with the reference category (p < 0.001). One possible explanation is that crews may be required to remain on scene while awaiting law enforcement, a coroner, or another appropriate official before clearing the scene. However, the present data do not permit a direct test of this explanation.

Agency ALS case share is also negatively associated with scene time. Agencies with a greater proportion of ALS responses tend to post shorter scene times (b = 1.602, p < 0.001). Because ALS case share is measured as a proportion, the coefficient represents the expected difference associated with moving from 0% to 100% ALS case share; a 10-per-

centage-point increase corresponds to approximately 9.6 seconds shorter on scene, so the full 0-100% switch represents a difference of 96 seconds. It could be argued that ALS case share partly reflects operational experience at the unit or agency level. However, rather than combining these concepts into a single measure, their independent associations with scene time were assessed separately.

The formal test of the primary hypothesis assesses the independent association between agency call volume and scene-time duration. Agencies in the top 20% of operational call volume have significantly shorter mean on-scene times than agencies in the bottom 80%. Sensitivity tests also assessed whether this result was affected by the selected cut point. Across these alternative thresholds, parameter estimates remained negative, under one minute in magnitude, and statistically significant at $p < 0.001$. Thus, the result does not appear sensitive to reasonable changes in how high-volume agency status is operationalized. In the primary specification, agencies in the top 20% of the call-volume distribution were approximately 36 seconds faster on average than agencies in the bottom 80% ($b = 0.600$, $p < 0.001$). Although 36 seconds may appear substantively modest for an individual response, small differences repeated across the large number of calls handled by high-volume agencies can accumulate into meaningful differences in system availability.

More notably, high-volume agency scene times are far more tightly concentrated around their means. This means that responders in the top 20% of agency by call volume more consistently post faster scene times across the distribution. They are extremely unlikely to exhibit unusually long agency-level median scene times. Examining the upper 5% of the agency median scene-time distribution, high-volume agencies are approximately eleven minutes faster at the margin than lower-volume agencies.

Operational exposure appears to matter most at the extreme end of the scene-time distribution, an important feature that analyses focused solely on central tendency might miss. The strongest pattern in these data may therefore be one of consistency rather than speed alone. High-volume agencies appear less likely to exhibit unusually long agency-level median scene times. Pattern recognition developed through repeated operational exposure may be one mechanism contributing to these results, although the present data cannot directly test that explanation. Taken together, the findings suggest that reliability in scene management may be as important an indicator of system performance as speed itself, with potential implications for training, supervision, and performance benchmarking in EMS agencies. Minimizing the risk of delays at the extreme end of the distribution may therefore represent an operationally meaningful point of intervention.

LIMITATIONS, CONCLUSIONS, & POLICY IMPLICATIONS

The study may suffer from omitted-variable bias because several potentially important determinants of scene time are unavailable in the data. These include the number of responders on scene, number and type of responding units, scene characteristics, weather, and other operational factors. In addition, agency call volume should not be interpreted as a direct measure of responder experience. Rather, it serves as a proxy for operational exposure at the agency level; individual years of service, training, certifications, and prior clinical experience are not available. The study is also only as reliable as the extent to which recorded data reflect on-the-ground realities and agency reporting practices. Future research could examine whether agency-level patterns in variables such as initial

acuity reflect differences in local practice, documentation, heuristics, or organizational routines.

This study relies on NEMSIS data, which capture a large and diverse share of EMS responses across the United States but necessarily reflect the structure, reporting practices, and operational norms of the U.S. EMS system. The magnitude and expression of these effects may differ in systems with alternative dispatch structures, staffing models, or clinical protocols. Nevertheless, the association between greater operational exposure and more consistent scene-time performance raises a broader question about whether similar organizational-learning patterns exist in other EMS systems. Future research incorporating qualitative interviews with field providers would further illuminate how experience shapes on-scene decision-making during 911 responses.

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RESEARCH REPORTS

UNDERSTANDING MATH ANXIETY THROUGH SELF-EFFICACY AND CULTURE: A MIXED-METHODS STUDY

Eihab Khasawneh, DDS, PhD, RN[1]; Ala'a Oteir, PhD[1]; Cameron Gosling, PhD[2]; Brett Williams, PhD*[3]

Author Affiliations: 1. Department of Applied Medical Sciences, Jordan University of Science and Technology, Irbid, Jordan; 2. Department of Paramedicine, Monash University, Melbourne, VIC, Australia; 4. Department of Emergency Medical Care, College of Applied Medical Sciences, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia.

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**Corresponding Author:* bawilliams@iau.edu.sa

ABSTRACT

Background: Health care providers' and students' performances may be impacted by math anxiety and self-efficacy levels. Many factors contribute to math anxiety and self-efficacy, such as bad grades in math at school and a lack of encouragement from parents or teachers. This study aimed to explore the difference in math anxiety and math self-efficacy for paramedic students at two universities in different cultures.

Methods: A sequential explanatory mixed-method study was conducted where data were collected using anonymous self-report questionnaires from students studying paramedicine at Monash University, Australia (n = 344) and Jordan University of Science and Technology, Jordan (n = 161), followed by face-to-face interviews.

Results: In multivariable regression, higher math self-efficacy was independently associated with lower math anxiety (B = 0.14, $p < .001$), and school country remained a significant predictor (B = 1.48, p = .024); interviews suggested motivation, self-confidence, and practice as perceived strategies to strengthen self-efficacy and reduce math anxiety.

Conclusion: This study, conducted in Australia and Jordan paramedic schools, addressed the relationship between self-efficacy and math anxiety among paramedic students. Math self-efficacy and math anxiety levels differed between the two schools according to sex, age groups, and study year level. Future research should focus on studying the effect of self-efficacy on math anxiety for practicing paramedics at national and international levels and focus on teaching and training strategies and interventions. The findings suggest that paramedicine programs should identify students with low math confidence early and use repeated, clinically contextualized medication-calculation practice, supportive feedback, and confidence-building activities to reduce avoidable anxiety before clinical placement.

INTRODUCTION

Math anxiety occurs when a person perceives a threat to their self-esteem in any situation that involves mathematics. It is a complex construct consisting of cognitive, behavioral, and affective responses to this perceived threat (Olango, 2016). Math anxiety is more than not liking math. Many people are genuinely fearful of math, and engaging in math-related tasks makes them feel nervous (Maloney & Retanal 2020). People then avoid math and math-related careers, potentially limiting future op-

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portunities (Olango, 2016). Math anxiety is widespread. A study by Beilock and Maloney (2015) in the US revealed that approximately 80% of college students enrolled in a certificate or associate degree, and 25% of students enrolled in a bachelor's degree, experience a moderate to high degree of math anxiety. Math anxiety has previously been linked to previous negative math experiences, such as being punished for not understanding or solving a math concept or problem and/or receiving a poor math grade, as well as not being encouraged by parents and teachers or having a positive role model (Smith & Penazzi, 2020). Math anxiety has been associated with academic failure and emotional tension (Barroso et al., 2021; Gürefe & Bakalım, 2018) and can lead to a loss of self-confidence, awareness, and poor learning (Arslanoglu & Ercan, 2017).

One component of self-confidence is self-efficacy. Self-efficacy is how a person judges their own capability in organizing and implementing a course of action that is required to achieve the desired performance (Bandura & Lightsey, 1999). Therefore, math self-efficacy is the confidence a person has in their own ability to solve a math problem or complete a math task (Zakariya, 2022). While better math skills have been shown to have a positive correlation with math self-concept and math self-efficacy, poorer math skill has been shown to have a negative correlation with math anxiety (Kaskens et al., 2020). An example of math self-efficacy is when a person achieves better results academically by using cognitive strategies to improve their belief in being able to complete tasks and develop alternative solutions (Gürefe & Bakalım, 2018). Studies have demonstrated that students who perceive they have high self-efficacy are more persistent and put more effort into achieving a difficult task (Arslanoglu & Ercan, 2017). In addition, studies have shown that students who have high math self-efficacy also have low math anxiety and value math more than students with low math self-efficacy (Hackett & Betz, 1989). Leppma and Darrah (2024) found that higher math anxiety existed in university students in non-STEM majors (compared to science, technology, engineering, and mathematics (STEM) majors) and that self-compassion and self-efficacy were predictive of math anxiety, while mindfulness was only significantly correlated to math anxiety and not predictive. They conclude that math anxiety is likely to be a key factor when a person avoids a STEM major or STEM profession.

Health care providers' and students' performances are also impacted by math anxiety and self-efficacy levels. For example, one study in paramedicine showed that learning and understanding science-based material (e.g., pharmacology) caused enough anxiety to influence the possibility of performing a medication error (Caffey et al., 2016). Johnson et al. (2020) note that a long-standing tension in nursing education is being able to develop the required math skills in nursing students to ensure the safe provision of prescribed medication doses. In a scoping study by Williams and Davis (2016), math anxiety, self-efficacy, teaching methods, and numerical ability were the four key factors identified that caused drug dosage calculation errors. Another study by Blanch et al. (2008) showed that female medical students reported lower self-efficacy and self-confidence, and higher anxiety, concerning math competence, even though they performed just as well as male medical students. In the paramedic discipline, LeBlanc et al. (2005) found that paramedics in high-stress conditions achieved lower accuracy scores when calculating drug dosage compared with the low-stress condition 43% vs. 58%. In another study, however, Eastwood et al. (2015) found that paramedic drug calculation accuracy was poor regardless of whether they were in a high-stress or low-stress situation. In

paramedicine, these concerns are especially relevant because medication calculations may need to be performed quickly, under pressure, and in environments where interruptions, fatigue, limited support, and patient acuity can increase the risk of error. Previous paramedic research has shown that drug calculation accuracy can be affected under stressful conditions, while other work has demonstrated that calculation accuracy may remain problematic even outside high-stress scenarios (Eastwood et al.. 2015; LeBlanc et al., 2005). For students, anxiety may therefore be linked not only to abstract mathematics, but also to practical tasks such as weight-based medication calculations, infusion rates, unit conversions, and volume-based dose calculations (Caffey et al., 2016; Johnson et al., 2020; Williams & Davis, 2016).

Math anxiety and self-efficacy are also highly influenced by cultural surroundings and not influenced so much by curricula goals or how curricula are implemented (Evans, 2014). All the previously mentioned studies were conducted within one cultural context, highlighting a gap in the literature and a limitation in terms of being able to generalize results across contexts. Investigation of math anxiety and its contributing factors in one context gives only part of the picture, leaving comparisons difficult and limiting conceptual understanding of cultural differences (Fan et al., 2019). Therefore, we conducted this cross-cultural study, which sought to analyze the differences in math anxiety and self-efficacy profiles between paramedicine students in Australia versus those in Jordan. Understanding these differences is important for paramedicine educators because it can help identify where students require more targeted support before they are expected to perform math-dependent clinical skills in simulation or clinical placement.

METHODOLOGY

Design and Participants

This is a sequential explanatory mixed-method study. Data was collected using anonymous self-report questionnaires from students studying a Bachelor of Paramedicine at Monash University, Australia (n = 344) and Jordan University of Science and Technology, Jordan (n = 161). The paper-based questionnaire was completed by students during the last 15 minutes of one of their classes. Participation was voluntary, and submission of the completed questionnaire implied consent. In the second part of the study, the students were invited to participate in a face-to-face structured interview. Integration occurred at two points: i) during the interviews, where interview questions were guided by quantitative findings, and ii) during interpretation, where quantitative and qualitative results were integrated across the two cultural contexts. Reporting of this study was guided in accordance with the GRAMMS (Good Reporting of a Mixed Methods Study) to maintain transparency in the reporting and integration of quantitative and qualitative results (O'Cathain et al., 2008).

Instrumentation

The Questionnaire

The questionnaire was composed of three parts: i) non-identifiable demographic information, ii) the modified Mathematics Anxiety Rating Scale (MARS) (Betz & Hackett, 2012), iii) the Mathematics Self-Efficacy Scale (MSES) (Betz & Hackett, 1983). The demographics section included questions asking participants their school's name, course year

level, age group, and sex. The questionnaire measured general math anxiety and math task self-efficacy; it did not ask students to identify anxiety related to specific paramedic medication-calculation formats, such as weight-based dosing, drip rates, or volume-based calculations. Participants self-reported their sex using the response options male, female, or prefer not to say.

Mathematics Anxiety Rating Scale (MARS)

Due to the length of the original 98-item math anxiety rating scale (Richardson & Suinn, 1972), a shorter 10-item scale was used in this study (Hopko et al., 2003). The 10-item scale has good reliability with a Cronbach alpha of .94 (McMullan et al., 2012) and is scored on a 5-point Likert scale for each item (1 = strongly disagree, 5 = strongly agree). The first five items were reverse-coded so that a high score indicates a high math anxiety level. Scores are reported as a total score out of 50 points.

Mathematics Self-Efficacy Scale (MSES)

In this study, the 18-question math task subscale of the MSES was used (Betz & Hackett, 1983). For each item on the math task subscale, individuals were asked to indicate their confidence in their ability to successfully perform the math tasks on a 10-point scale ranging from "no confidence at all" (1) to "complete confidence" (10). The final score for the MSES task subscale can range from 18 to 180 points. The overall scale has good reliability with a Cronbach alpha of .92 (Betz & Hackett, 1983).

The Interviews

Interviews were carried out using a structured interview guide that explored participants' perceptions of the effect of self-efficacy on math anxiety. The interviewer was not directly involved in the program development or delivery and was not known to the participants. The interviews were digitally recorded and transcribed verbatim.

Ethical Statement

The study was carried out according to the Declaration of Helsinki. The project was approved by the Monash University Human Research Ethics Committee (Project number: 17969) and Jordan University of Science and Technology Institutional Review Board (IRB) (Reference: 33/127/2019). Written informed consent was obtained from all interview participants prior to the interview commencing and data collection. The questionnaire was administered anonymously with no collection of identifiable data, and submission of the completed questionnaire implied consent.

DATA ANALYSIS

Phase 1: The Questionnaires

Data was compiled, and IBM SPSS Statistics (Version 26) was used for analysis. Data are presented using descriptive statistics, including mean ± standard deviations (SD), interquartile range (IQR), or frequency and proportions where appropriate. Preliminary analyses were performed to make sure there was no violation of the assumptions of normality, linearity, and homoscedasticity. Independent samples, student's t test, one-way ANOVA, and post-hoc tests were used to compare mean differences between groups where appropriate. Linear regression was used to identify the factors that were associ-

ated with math anxiety. Univariate regression with the dependent variable was used to analyze each predictive independent variable. Variables that were significant at $p < 0.20$ were then entered into a multivariate model. The level of significance was assigned at $p < 0.05$, and the effect size was calculated.

Phase 2: The Interviews

Interviews were conducted by one of the researchers (Khasawneh). First, each participant was reminded of the purpose of the study, the benefits of the research, the research and confidentiality procedures, and their right to withdraw from the study at any time. Consent was obtained in writing and verbally in advance of the interview. All the interviews were audio-recorded with no time limit for ending the interview. Notes were taken by a research assistant during the interviews, which enabled the researcher to track key points to return to later in the interview and for use during data analysis. All recordings were then transcribed verbatim and translated into English. Each interviewee was labeled by the letter J followed by a number for Jordan University of Science and Technology students, for example, interviewee number 1 was labeled as (J1). Each interviewee was labeled by the letter M followed by a number for Monash University students, for example, interviewee number 1 was labeled as (M1). The interviews for Jordanian students were conducted in the Arabic language by Khasawneh, who speaks Arabic and English, and they were sent to a translation agency to be translated into English. The recorded interviews were immediately transcribed as spoken in Arabic. The translation was performed by a professional translator, and the Arabic interviews were translated into English. Using the method of back translation, translators were able to back-translate some of the interview transcripts from English to Arabic to ensure the accuracy of the transcripts (Choi et al., 2012; Driscoll et al., 2007). All data was then checked by Khasawneh by listening to the audio recordings and comparing them to the transcripts (Choi et al., 2012). The interviews for Australian students were conducted in English by Khasawneh.

All transcripts were coded by Khasawneh, and Williams coded a subset of transcripts. Open coding was used throughout, enabling areas requiring additional data and/or new lines of inquiry to be identified. This initial coding remained open to any possibilities that could be discerned in the data, and to reduce the possibility of any conceptual leaps happening during the analysis. The interviews were analyzed using qualitative content analysis. First, transcripts were read through multiple times to gain an overall perspective. Transcripts were then reread and split up into meaning units, each representing a single unit of content (Driscoll et al., 2007).

RESULTS

Phase 1: The Questionnaires

This study involved a total of 505 students; 344 students (68%) participated from Australia (Monash University), and 161 students (31%) participated from Jordan University of Science and Technology. This represents an 81% and 75% response rate from Monash University and Jordan University of Science and Technology, respectively. The demographic profiles of the consenting participants are reported in Table 1. Most of the participants from Monash University were from the first-year cohort (45.9%), female (63.4%), and aged from 20 to 24 years (50.6%). On the other hand, most of the participants from

Jordan University of Science and Technology were from the third-year cohort (32.9%), female (65.2%), and aged 20 to 24 years (54.7%).

	Monash University Number (%) n = (100%)	Jordan University of Science and Technology Number (%) n = (100%)
Sex		
Male	125 (36.3)	56 (34.8)
Female	218 (63.4)	105 (65.2)
Prefer not to say	1 (0.3)	---
Age Group		
≤19	125 (36.3)	58 (36.0)
20-24	174 (50.6)	88 (54.7)
≥25	45(13.1)	15 (9.3)
Year Level		
1st Year	158 (45.9)	40 (24.8)
2nd Year	87 (25.3)	46 (28.6)
3rd Year	99 (28.8)	53 (32.9)
4th Year	---	22 (13.7)

Table 1. Demographic data for Monash University and Jordan University of Science and Technology paramedicine students.

Mathematics Anxiety Rating Scale

The MARS scores are shown in Table 2. MARS scores for Jordan University of Science and Technology students ranged from 10 to 42 points, while those for Monash University students ranged from 10 to 50 points. The mean (SD) scores for Monash University students (25.7 (±8.9)) were lower than for Jordan University of Science and Technology students (29.3 (±4.9)). The independent samples t test showed that there was a significant difference in MARS mean scores between Monash University students and Jordan University of Science and Technology students: t (503) = -4.8, 95% CI [-5.1, -2.1], $p < 0.001$, $d = 0.50$.

In addition, there was a significant difference in the MARS mean scores for the male students (t (179) = -4.9, 95% CI [-8.1, -3.4], $p < 0.001$, $d = 0.84$) and the female students (t (321) = -2.5, 95% CI [-4.2, -.5], $p = 0.001$, $d = 1.0$) between Monash University and Jordan University of Science and Technology students. While the independent samples t test showed that there was a significant difference in MARS mean scores between males and females (t (341) = -3.6, $d = 0.40$, $p < 0.001$ for Monash University students), it showed that there was no significant difference in MARS scores between males and females among Jordan University of Science and Technology students (t (159) = -0.122, $d = 0.02$, $p = 0.9$).

In comparing the MARS mean scores of different year levels, the one-way ANOVA showed that there was a significant difference between the two schools in the mean scores for the first-year students (F (1, 196) = 7.1, $p = 0.008$) and the third-year students (F (1, 150) = 10.3, $p = 0.002$). There was a statistically significant difference in MARS mean scores between Monash University students' year level (F (2, 341) = 3.8, $p = 0.02$). However, there was no statistically significant difference in MARS mean scores between Jordan University of Science and Technology students' year level (F (3, 157) = 2.4, $p = 0.07$). Post-hoc comparisons using a Gabriel test indicated that the MARS mean score for Monash University students who are at year one level was significantly different from those who are at year two, $p = 0.019$. Year three students' MARS mean scores did not differ significantly from year one and year two students' mean MARS scores.

There was a significant difference in the MARS mean score between the two schools for the students who were aged between 20-24 years (F (1, 260) = 22.3, $p < 0.001$). In contrast to Monash University students, whose MARS mean scores were not significantly different between age groups (F (2, 341) = 0.85, $p = 0.43$), the Jordan University of Science and Technology students' MARS mean scores were significantly different between age

groups (F (2, 158) = 3.2, p = 0.045). Post-hoc comparisons using a Gabriel test indicated that the MARS mean score for Jordan University of Science and Technology students differed significantly between those who are ≤ 19 years and those who are between 20-24 years old, p = 0.038.

Mathematics Self-Efficacy Scale

The MSES scores are reported in Table 2. MSES scores for Jordan University of Science and Technology students ranged from 33 to 167, while for Monash University students from 46 to 180. The mean (*SD*) MSES scores for Monash University students were 125.7 (29.3), while for Jordan University of Science and Technology students were 110.6 (27.3). The independent samples t test showed that there was a significant difference in MSES mean scores between Monash University students and Jordan University of Science and Technology students; t (503) = 15.8, 95% CI [9.7, 20.5], p < 0.001, d = 0.53.There was a significant difference in the MSES mean scores for the male students (t (179) = 6.7, 95% CI [19.9, 36.5], p < 0.001, d = 0.33) and the female students (t (321) = 2.2, 95% CI [.9, 14.4], p = 0.001, d = 0.27) between Monash University and Jordan University of Science and Technology students. While the independent samples t test showed that there was a significant difference in MSES mean scores between males and females (t (341) = 5.5, d = 0.62, p < 0.001) for Monash University students, it showed that there was no significant difference in MSES scores between males and females in Jordan University of Science and Technology students (t (159) = -0.72, d = 0.12, p = 0.90).

In comparing the different year levels' effect on the MSES mean scores, there was a significant difference between the two schools in the mean scores for the first-year students (F (1, 196) = 11.1, p = 0.001) and the third-year students (F (1, 150) = 15.6, p < 0.001). There was a statistically significant difference in MSES mean scores between Monash University students' year level (F (2, 341) = 6.8, p = 0.001). Post-hoc comparisons using a Gabriel test indicated that the MSES mean score for students who are at the year two level was significantly different from those who are at the year one level (p = 0.001) and the year three level (p = 0.001). Year three students' MSES mean scores did not differ significantly from year one scores. There was no statistically significant difference in MSES mean scores between Jordan University of Science and Technology students' year level (F (3, 157) = 0.71, p = 0.06). There was a significant difference in the MSES mean score between the two schools for the students who are aged between 20-24 years (F (1, 260) = 18.6, p < 0.001) and those who are aged older than 25 years (F (1, 58) = 25, p < 0.001). In contrast to the Monash University students' MSES mean score, which is significantly different between age groups (F (2, 341) = 9.5, p < 0.001), the Jordan University of Science and Technology students' MSES mean score was not significantly different between age groups (F (2, 158) = 2.3, p = 0.109).

Scale Reliability

Cronbach's alpha reliability for MARS in this study was 0.88, and the MSES was 0.92. This indicated that both scales had good reliability.

Predicting Math Anxiety Levels

First, the linearity between dependent and independent variables, normality, homoscedasticity, and multicollinearity were assessed. The enter method of entry was used to

enter the independent variables that included school, year level, sex, age, and math self-efficacy level. A multiple linear regression analysis was then carried out. In the multivariable model, higher math self-efficacy was associated with lower math anxiety (B = -0.14, $p < 0.001$) and school location was also independently associated with math anxiety (B = 1.48, $p = 0.024$). Sex was not statistically significant ($p = 0.158$) (Table 3).

	MARS Score		MSES Score	
	Monash University	Monash University	Jordan University of Science and Technology	Jordan University of Science and Technology
	M (SD)	M (SD)	M (SD)	M (SD)
Sex				
Male	23.44 (7.95)*	29.21 (5.7)*	136.71 (25.7)*	108.50 (27.5)*
Female	26.92 (9.10)*	29.31 (4.5)*	119.40 (29.6)*	111.75 (27.3)*
Age Group				
19	26.50 (8.4)	28.06 (4.8)	120.65 (27.9)	116.60 (24.6)
20-24	25.31 (8.9)*	30.12 (4.9)*	125.03 (31.7)*	107.57 (29.4)*
25	24.93 (10)	29.00 (4.5)	142.24 (21.2)*	105.29 (21.3)*
Year Level				
1st Year	24.74 (8.1)*	28.25 (4.1)*	130.21 (26.3)*	114.75 (25.7)*
2nd Year	27.93 (9.1)	28.45 (4.7)	116.14 (32.8)	112.28 (25.8)
3rd Year	25.25 (9.7)*	29.88 (5.6)*	112.86 (29.0)*	107.32 (29.1)*
4th Year	---	31.22 (1.6)	---	107.59 (29.2)

Table 2. A comparison of MARS and MSES scores between Monash University and Jordan University of Science and Technology students.
*Note: * Level of significance was assigned at p < .05. M: Mean; SD: Standard Deviation.*

Factor	Coefficient	95% CI	*p*-Value
MSES	- 0.14	[- 0.16, - 0.12]	<.001
School location • Monash University • Jordan University of Science and Technology	(Reference) 1.48	[0.2, 2.77]	0.024
Sex* • Male • Female	(Reference) 0.89	[- 0.34, 2.12]	0.158

Table 3. Regression model summary.
*Note: * Data from the single participant preferring not to identify sex was removed from the regression analysis. CI: Confidence Interval; MSES: Mathematics Self-Efficacy Scale*

Phase 2: Interview Evaluation

The results of the qualitative phase were based on interviews with 16 students. Ten of the interviews were conducted through a face-to-face method (six students from Jordan University of Science and Technology and four from Monash University), and six interviews via telephone (two from Jordan University of Science and Technology and four from Monash University). Females comprised 75% of the participants. Most interview questions were asked as they were written. However, where appropriate and needed, the researcher followed up questions with open-ended prompt questions such as "Why?" and "Could you please explain more?" This enabled the researcher to gain deeper meaning and a richer understanding of participants' experiences. The themes that emerged from the interviews that were related to math anxiety and self-efficacy included: mathematical concepts and operations, motivation, self-confidence, and practice.

Mathematical Concepts and Operations

Participants had different views regarding the difficulty of certain mathematical methods. For example, some participants argued that division is a more difficult mathematical operation than multiplication because it is a time-consuming procedure; (J4) stated that "I feel dividing needs more time, unlike multiplication, which can be done quickly. The idea is that division needs more time." Another student, (J8), stated that "I guess

division is the hardest calculation." On the other hand, other participants reported that addition and multiplication are the most difficult mathematical methods; (J5) stated that "I guess addition is the most difficult mathematical operation" and (M4) reported that "Yeah, probably multiplication and stuff. Just stuff without a calculator basically."

One participant argued that failure to have good mathematical competency due to anxiety might lead to some errors in paramedic practice in the field; (J5) stated that "Sure, because there is something called medication calculation. Meaning, there are certain doses that a paramedic needs to pay attention to. If the dose increases, many complications can occur to the patient." This response linked math anxiety directly to medication safety, suggesting that students viewed mathematical confidence as part of safe paramedic decision-making rather than as a purely academic issue.

Motivation

Motivation is one of the factors that can improve a person's self-efficacy. Factors that might contribute to increased motivation levels involve role modeling, the impact of peers, and the family. (J1) stated that:

> *It plays a big role. In terms of personality enhancement, through encouragement can enhance your personality. From an environmental perspective, the people around you influence you, so you find people trying to frustrate you, and you must overcome these things, in addition to the difficulties of life. Meaning that you try as much as you cannot be affected by these things and enhance yourself.*

Another student claimed that the community around you can motivate the person to practice more efficiently by enhancing self-efficacy of the person. (J5) stated that "I think motivation has a lot to do with, especially the one that comes from the family and the society. This motivation creates an incentive for the individual to do more."

Role modeling plays an important role in increasing personal motivation toward achieving goals. (J5) stated that:

> *This effect is dependent on the role model. If your role model is a person who is successful and has wide knowledge and understanding at work. Then you start feeling that he is perfect, and this encourages you to be like him and feel that you are longing to learn.*

Another participant argued that family has the most effect on motivation; (J5) stated that "In my opinion, the family accounts for 80% of motivation."

Self-Confidence

Self-confidence is very important in healthcare practice. Participants reported that self-confidence is related to self-efficacy and can positively impact the math anxiety level; (J2) stated that:

> *Belief in abilities means believing that you can do something even if it is wrong. In an emergency, if you make a mistake, you will not remain in your place even if you make a mistake one or two times. Frankly, I suffer from this. Belief in abilities means that you do not give up if you make a mistake once because you must try again with training and practise until you reach a level of 100% mastery and get rid of this problem.*

Participant (M5) argued that stress can be reduced when you have a higher confidence level. (J1) stated that:

> *They're almost inseparable. While you try to trust yourself, you fear failure. Here, you must control and convince yourself that there are people who fail only because the stress has taken over. Here, I think you should train to control yourself and not allow anything to provoke you or frustrate you while weighing your self-confidence.*

Participant (M3) reported that:

> *I get nervous simply because it's not something I practice all the time, so it's not my most comfortable strength. So again, because I do get anxious (because it's not my most confident skill) nerves impact any sort of performance.*

Practicing

Practice is very important to achieve competency in any math-related skill. Participants argued that solving more mathematical problems can improve the ability of the person to perform these skills in all situations. (J3) stated that "mathematics needs intelligence as well as a continuation of solving mathematical calculations." (J6) stated that:

> *I was able to overcome this problem by practice. Gradually, I began to practice and understand, especially with the solution of many mathematical problems. Here, I discovered that mathematics relied primarily on solving many problems.*

Another participant (J8) stated that "Negligence is on the part of the student himself, refraining from practicing such types of calculations, and refraining from following up well may create the problem for him."

One participant argued that self-efficacy and math anxiety is related to the amount of experience and practice that the person can do. (J1) stated that:

> *They almost complement each other. If you have experience, your faith in your abilities will improve. This has already happened to me. If you have the necessary experiences, you can act in the situations you are exposed to. They are complementary to one another and cannot be separated.*

Another participant (M8) stated that:

> *I would do a lot of practice with a friend who has got a good maths brain and he always just knew it and got it and I just could not. So yeah, I was sort of a bit discouraged that he was so good at it and could just see it and was getting good marks.*

The merging of the results from both the qualitative and quantitative analyses indicated that mathematical concepts and operations, motivation, self-confidence and practicing are the main themes that were related to math anxiety and self-efficacy. The participants reported that self-efficacy and math anxiety are important concepts in paramedic practice. When integrated, the results suggest that the negative association between math self-efficacy and math anxiety reported by the quantitative analyses is explained by qualitative themes of confidence, motivation, and practice, while cross-cultural differences are further explained by contextual variations in pedagogical experiences and support provided by the university.

DISCUSSION

To our knowledge, this study is among the first cross-cultural comparative studies in paramedicine to explore math anxiety and math self-efficacy in paramedic students at two universities in different cultural contexts. Our study reported that Jordanian paramedic students have higher levels of math anxiety and lower levels of self-efficacy compared to Australian students. Math self-efficacy level and the school (cultural background) were the contributing factors to math anxiety.

Math self-efficacy among Jordanian students was lower than that among Australian students. Our findings contrast with those reported by Mueller and Goic (2003), who found no significant differences in self-efficacy when comparing undergraduate business students in the United States and Croatia. Moreover, our findings were in contrast with Basil and Karatuna's (2017) study, which found that there were no significant differences in the level of self-efficacy between the students of economics and administrative sciences in Poland and Turkey.

We found that as students progressed through their paramedic education in both schools, the mean self-efficacy level decreased. Our finding is unlike Marra et al. (2009) study on engineering students in the US, who found that progression in the year level of study would improve self-efficacy. From the interviews in our study, we found that one factor that might affect self-efficacy level was positive self-confidence. Self-confidence and self-efficacy are often used interchangeably; however, self-confidence does not necessarily mean a positive outcome and refers only to the strength of certainty of a person's belief (Bandura & Lightsey, 1999). For example, a person may be confident in failure. The participants felt that having positive self-confidence can increase self-efficacy because self-confidence has a considerable effect on the outcome and performance (Barrows et al., 2013).

One interesting finding in our study was that, in contrast to the Australian female students, the Jordanian female students had higher self-efficacy levels than their male counterparts. Our finding is inconsistent with a Turkish study involving 1679 students studying at Anadolu University (Satici & Can, 2016). This study reported that male students had higher self-efficacy scores than female students (t (1677) = 5.47, $p < 0.01$), which indicated that sex impacted the self-efficacy level. Another study conducted at an Albanian university found that male students (M = 3.06, SD = 0.74) also had higher self-efficacy than female students (M = 2.67, SD = 0.89) (Shkullaku, 2013). In the Albanian culture, sex role stereotypes are very powerful, and therefore, females' capacities are undermined by male capacities (Shkullaku, 2013). In Jordan, traditional sex stereotyping and male dominance have started to decrease in the last few decades. This makes the percentage of students in tertiary education who are female (%) in Jordan to be reported at 52.92% in 2017 (Dandan & Marques, 2017).

Our study found that the math anxiety levels were higher in Jordanian students, which indicates that cultural background might impact math anxiety levels. This finding is similar to Hamza and Helal (2013), who studied the math anxiety difference between American and Egyptian students and reported a significant main effect for countries (F (1, 187) = 11.41, $p < 0.001$) on math anxiety levels. Hamza and Helal (2013) argued that the Egyptian educational system might contribute to the difference in math anxiety levels.

Brown et al. (2020) point out that different cultures have different knowledge and values based on different interests, and different countries have different education systems with different policies, curricula content, guidelines, and models based on development agendas and expectations these agendas generate. Brown et al. (2020) also reported that differences in math anxiety between engineering students from Germany and Mexico were attributed to differences in their cultures' attitudes and beliefs. In Jordan, the paramedic program is a four-year program where the students in the first year are enrolled in basic science classes. Math is not part of these basic sciences. This means that students' first use of mathematics related to their paramedic study would be in the third year in the pharmacology class. A study conducted by Kalaycioglu (2015) also suggests that different education systems influence differences in the math anxiety levels of students in different countries. She suggests that Turkey, Greece, and Hong Kong are countries that are more centralized and, as a result, present students with more challenges, such as high-stakes testing to rank and allocate students into schools. In these countries, access to certain schools based on test scores starts when a child is around 11 years old. One of the most widespread studies across cultures was a study by Lee (2009) involving 276,165 students, 15 years of age, from 41 countries, that showed that students from Western Europe obtained scores that showed the strongest connection between math self-concept and math achievement, and students from Asia and Eastern Europe obtained scores that showed the strongest connection between self-efficacy and math achievement. In addition, students from Western and Eastern Europe obtained scores that showed the strongest connection between math achievement and math anxiety (compared with Asian students). Furthermore, students from some of the Western European countries (such as the Netherlands) experience low math anxiety (Lee, 2009).

While our study showed that sex impacted math anxiety levels for Australian students, it did not impact the math anxiety levels for Jordanian students. This finding aligns with a study conducted by Hamza and Helal (2013), who reported that in Egypt and America, math anxiety was not influenced by sex and is inconsistent with the conclusions of Xie et al.'s (2024) meta-analysis study, which reported that females, especially adult women, experience more math anxiety than men. However, a more recent study with American students by Leppma and Darrah (2024) showed that male students experienced less math anxiety than female students. In another study by Khasawneh et al., (2021) with paramedicine students, math anxiety was negatively correlated to self-efficacy, and both of these factors were influenced by sex.

Our study found that self-efficacy and the school location (cultural background) were predicting factors for math anxiety in this sample of paramedic students. This indicates that higher self-efficacy was associated with lower math anxiety in this sample, although causal relationships cannot be inferred from the cross-sectional design. A variety of ways to reduce math anxiety are suggested in the literature, including student-directed learning; supportive, caring, and positive learning environments; and learning that is flexible enough to meet the needs of students with different learning styles (McMullan et al., 2012). Participants in our interviews claimed that math anxiety could be reduced by increasing mathematical competency. Other students claimed that continuous practicing and enriching their personal experience would improve self-efficacy, which would, in turn, decrease the math anxiety level among the students. Moreover, the participants argued that motivation through family positive reinforcement and positive role modeling

could increase the self-efficacy level. This was consistent with a McMullan et al.'s (2012) study on British nursing students who reported that constructive feedback, evaluative feedback (i.e., effort or ability), and encouragement all help to increase self-efficacy and/or achievement. More recent approaches to improve math self-efficacy and reduce math anxiety in students include mindfulness, growth mindset interventions (Samuel & Warner, 2021), activities to improve working memory (Pellizzoni et al., 2022), contextualized, practical and collaborative learning approaches (Pettigrew et al., 2020), gaming apps that develop numeracy (Abdul-Mumin et al., 2025), and web-based tools that teach logic and make math accessible, and even humorous (Fronberg, 2021). For paramedicine educators, these findings suggest several practical curriculum considerations. First, medication numeracy should be introduced early and revisited regularly, rather than being concentrated only in pharmacology subjects. Second, practice should use authentic paramedic examples, including weight-based dosing, infusion calculations, unit conversion, and volume-based medication calculations. Third, educators should normalize math anxiety, provide low-stakes practice before assessment, and give feedback that builds self-efficacy as well as technical accuracy. These educational strategies may help students develop calculation confidence before entering high-pressure clinical environments.

LIMITATIONS AND FUTURE RESEARCH

There are a number of limitations to our research. This study used a convenience sample approach, which may hinder the generalization of results. Self-reporting questionnaires could also be seen as a limitation, where results are dependent entirely on how students respond to items and assumptions about student honesty. Furthermore, using a thematic analysis approach could mean a narrower insight into study concepts. Another limitation of this study relates to the translation of interviews conducted with Jordanian students, as the translation process may have posed a threat to validity by limiting the nuanced representation of participants' original meanings (Choi et al., 2012). The study also did not examine whether students experienced anxiety with particular medication-calculation types, nor did it collect data on whether any students failed or were delayed in the program because of math anxiety or medication-numeracy performance. These issues should be examined in future paramedicine education research.

Future research should examine practicing paramedics to better understand how math anxiety influences clinical performance and math-dependent skills such as drug dose calculations. Further work could also explore the relationship between math anxiety, self-efficacy, numerical ability, and cognitive processing across different cultural contexts. In addition, intervention studies should evaluate whether strategies such as structured medication-calculation teaching, repeated simulation-based numeracy practice, and early identification of low math self-efficacy can reduce anxiety and improve calculation performance.

CONCLUSION

This study, which was conducted in Australia and Jordan paramedic schools, explored the relationship between self-efficacy and math anxiety among paramedic students. Math self-efficacy showed a negative correlation to math anxiety in paramedic students. Math self-efficacy and math anxiety levels differ between the two schools according to sex, age groups, and the study year level. Future research should focus on studying the

effect of self-efficacy on math anxiety for practicing paramedics at national and international levels. Moreover, developing teaching or training strategies to reduce the math anxiety level among paramedic students should be tested in future studies by exploring the role of other factors, such as motivation, self-confidence, mindfulness, collaborative learning, as well as improving working memory, practicing skills, and self-reflection. Based on these findings, paramedicine programs should consider embedding regular medication-calculation practice across the curriculum, using clinically relevant examples, supportive feedback, and early identification of students who report low math self-efficacy.

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RESEARCH REPORTS

INTEGRATED FIELD MONITORING OF PARAMEDIC WORKLOAD AND EXPOSURE: A MULTI-MODAL METHODOLOGICAL STUDY

Alex MacQuarrie, RP, PhD*[1]; Matt Stainer, PhD[2]; Eric Drinkwater, PhD[3]; Peter Micalos, PhD[4]; James Crane, PhD[5]; James Wickham, PhD[6]

Author Affiliations: 1. Health Sciences and Medicine, Bond University, Robina, QLD, Australia; 2. Griffith University, Nathan, QLD, Australia; 3. Deakin University, Burwood, VIC, Australia; 4. Biomedical Sciences, Charles Sturt University, Bathurst, NSW, Australia; 5. School of Medicine, University of Tasmania, Hobart, TAS, Australia; 6. Science and Health, Charles Sturt University, Orange, NSW, Australia.

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*Corresponding Author:
smacquar@bond.edu.au

ABSTRACT

Introduction: Paramedics experience demanding physical tasks, acute stressors, and chronic under-recovery, defined as an accumulation of incomplete physiological and psychological recovery. However, occupational exposure research has primarily relied on retrospective self-report, simulation, or single-modality monitoring that poorly capture within-shift variation and operational context.

Objective: The objective of this paper was to describe, implement, and evaluate a field-embedded, multi-modal protocol for measuring paramedic occupational exposure across routine rostered shifts, cross-referenced to CAD data. Specifically, we report protocol feasibility, data completeness, artifact burden, and field validity as methodological endpoints.

Methods: We conducted a prospective methodological observational study embedded in the routine operations of a large Australian ambulance service. A workforce-aligned sample of operational paramedics completed multiple monitored shifts wearing Hexoskin smart garments for continuous heart rate, respiratory rate, and accelerometry data, with pre-/post-shift and pre/post call blood pressure measurement and Borg Rating of Perceived Exertion (RPE) where feasible. Anonymized computer-aided dispatch (CAD) records provided call type, priority, and phase timestamps (assign, en route, on scene, to hospital, at hospital), enabling minute-level linkage with biometric data. Standardized procedures were specified a priori for recruitment, device fitting, shift monitoring, logbooks, data export, cleaning, missing-data thresholds and an epoch-based hierarchical data structure (epochs within calls, calls within shifts, shifts within paramedics). Primary procedural endpoints were feasibility and adherence, data completeness and artifact profile, and field validity of Hexoskin measures.

Results: Thirty-two paramedics completed 232 monitored shifts, yielding 918 emergency calls and approximately 2,700 hours of analyzable multi modal monitoring. Protocol adherence was high, with most rostered monitoring opportunities proceeding as planned and shifts meeting the predefined 75% biometric data completeness threshold despite approximately 5% of ECG data being removed as artifact. Hexoskin heart and respiratory rate patterns demonstrated expected gradients across CAD-defined call priorities and operational phases. They were consistent with prior laboratory validation, supporting the field validity of the protocol.

Conclusions: This protocol provides a replicable, EQUATOR-aligned framework for multi-modal paramedic exposure research that could be adapted to other emergency services. By foregrounding design, measurement, data processing, and analytic structure, it provides methodological infrastructure to support future etiologic and intervention studies.

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INTRODUCTION

Paramedics face substantial physical and psychological demands, with evidence of elevated cardiometabolic risk, fatigue and sleep disruption compared with the general population (Alenazi et al., 2016; Buljan et al., 2016; Kearney et al., 2021). However, existing occupational exposure studies in paramedicine have relied heavily on surveys and simulations, sometimes supplemented by monitoring, which has limited in situ ecological validity and the ability to link physiological responses to specific calls or operational phases (Janka & Duschek, 2018; Morales et al., 2016).

Despite the potential availability of computer-aided dispatch (CAD) data and wearable "smart garments," there is no widely accepted, transparently reported methodology for integrating biometric, subjective, and operational data in paramedic field settings. Methodological studies that explicitly develop and evaluate such protocols are needed to support reproducible, scalable occupational exposure research. This paper is intended as a methodological and feasibility report rather than a definitive exposure-outcome analysis. The exemplar findings are presented to demonstrate protocol performance, data capture, and field validity; substantive occupational exposure analyses arising from this cohort will be reported separately.

OBJECTIVE

This paper presents a transparent, field tested protocol for paramedic occupational exposure research. It integrates wearable biometric monitoring, subjective exertion ratings, and CAD data. It also reports key indicators of feasibility, data quality, and field validity as exemplar outcomes of protocol performance.

To achieve this, the study pursued three specific aims:

1. To integrate wearable biometric monitoring, intermittent blood pressure measurement, perceived exertion ratings, and CAD derived operational timestamps into a single shift level monitoring protocol that can be embedded within routine ambulance operations.
2. To quantify protocol feasibility and adherence, including recruitment, monitored shifts per participant, and the proportion of rostered shifts and emergency calls successfully captured and linked across data streams.
3. To characterize data quality and field validity by describing biometric data completeness, artifact burden, and expected physiological gradients across CAD defined call priorities and operational phases as exemplar outcomes of protocol performance.

METHODS

Study Design and Setting

We conducted an observational methodological study embedded in the routine operations of a large Australian state ambulance service (n = 3,302), in which we both developed and evaluated a multi modal field protocol. An a priori sample size calculation indicated that 27 participants would be sufficient for the planned exemplar mixed-effects analyses; accordingly, a recruitment target of 28 was set to allow for minimal attrition. Because participant interest exceeded this target and operational monitoring capacity

permitted additional enrollment, 32 paramedics were ultimately included. The power analysis should be interpreted in the context of the study's methodological rather than etiologic focus. Data was collected over 7 months of rolling recruitment, with shift monitoring conducted during routine rostered duties. The study was reported in accordance with STROBE for observational studies and emerging EQUATOR guidance for methodological research.

Participants and Sampling

Operational paramedics rostered to front-line duties were eligible; staff in desk-based roles, recent significant musculoskeletal injury, pregnancy, and those prescribed heart-rate-limiting medications were excluded. We used workforce-aligned sampling to mirror the distribution of age, sex, clinical level, and posting (metropolitan versus regional) across the service, recruited through internal communications linked to a broader health and workload survey and local station presentations (High, 2015). Interested staff contacted the research team and provided written informed consent.

Operational context variables recorded for each monitored shift included roster characteristics and CAD-derived call information. Environmental variables such as ambient temperature and humidity were not recorded. The response platform was a two-paramedic staffed ambulance. Paramedics followed a shift rotation of four 12-hour shifts (2 days and 2 nights) followed by 5 days off.

Measurement Framework

Primary methodological outcomes were feasibility and adherence, data completeness and artifact profile, and field validity indicators of Hexoskin measures, with operational characteristics from CAD treated as exposures.

Biometric Monitoring

Continuous biometric monitoring using Hexoskin smart garments (Carre Technologies, Montreal, Quebec), incorporating a digital ECG and dual respiratory bands to capture heart rate (HR), respiratory rate (RR), accelerometry-derived activity (G-force), and step count. Heart rate was derived from R-R intervals, and respiratory rate and volumes were measured with calibrated respiratory bands; prior validation shows minimal bias and high agreement with criterion measures across rest and exercise, supporting field use by paramedics (Cherif et al., 2018; Elliot et al., 2017; Moriarty et al., 2018; Villar et al., 2015).

Blood Pressure and Perceived Exertion

Blood pressure (BP) was measured intermittently using the LIFEPAK 15 monitor/defibrillator (Stryker, Kalamazoo, MI, USA), which employs oscillometric measurement with a manufacturer-reported accuracy of ±5 mmHg across the operating range for systolic, diastolic, and mean arterial pressure (Stryker, 2022). The LIFEPAK 15 monitor/defibrillator underwent routine service maintenance and pre-use operational checks in accordance with organizational practice. Measure was recorded as systolic and diastolic blood pressure taken pre- and post-shift, and, when feasible, after calls perceived as particularly demanding. Mean arterial pressure (MAP) was then calculated using a standard formula (DeMers & Wach, 2025). Perceived exertion was assessed with the previously validated Borg 0-10 Rating of Perceived Exertion (RPE) scale (Borg, 1982; Tobase

et al., 2024) immediately before and after each monitored shift and, where operationally possible, after individual calls or at mid-shift.

Demographic and Occupational Characteristics

Baseline characteristics included age, sex, anthropometry, clinical level, posting (metropolitan vs regional), and years of service overall and at the current level. These measures were consistent with prior paramedic workload and health research to support interpretation and external comparability (Hunter et al., 2019).

Computer-Aided Dispatch Data

Emergency medical calls at this service are managed using the VisiCAD Command computer-aided dispatch system (TriTech Software Systems, FL, USA). For each monitored shift, anonymized CAD records provided a call identifier, type, priority code, and timestamps for the assign, en route, on scene, to hospital, and at hospital phases, which were used to time-anchor biometric and subjective measures and to define exposure epochs.

Field Protocol

The protocol was designed to integrate with routine workflows and minimize disruption.

1. Orientation and familiarization: Participants attended a brief training session in person or virtually, covering garment fitting, data pack charging, syncing, BP measurement, RPE recording, and use of a simple shift log; test recordings were used to confirm signal quality and competence.
2. Pre-shift baseline: At the start of each monitored shift, participants donned the garment under their uniform, confirmed electrode contact, and sat quietly for at least five minutes to capture baseline HR, RR, and G-force, then recorded baseline BP and RPE.
3. During shift: Hexoskin recorded continuously, including breaks; BP was repeated when feasible after demanding calls and at the end of shift; RPE was recorded after each call or, where call volume was high, at least mid-shift and end-of-shift; logbooks captured device issues.
4. Post-shift: At shift end, participants repeated BP and RPE, removed the garment, and followed standard cleaning and charging procedures; data were uploaded via encrypted connections to a secure server. At the end of all shifts, the equipment was returned to the researcher in pre-paid postal packaging.

Data Management, Cleaning, and Structure

Hexoskin data were downloaded as binary data files. Time-aligned BP, RPE, and CAD timestamps were created in Excel (Microsoft, USA) and merged with the Hexoskin data file using Vivosense analytical software (Vivosense, San Diego, CA). Each shift was structured hierarchically: epochs (operational phases) nested within calls, which were nested within shifts, which were nested within paramedics. For each epoch and across the entire shift, we derived mean and peak HR and RR, G-force, most proximal BP and RPE, and CAD data, preserving temporal ordering and enabling multilevel modeling of physiological responses to operational exposures.

Physiologic time series underwent visual and algorithmic screening for artifacts, including non-physiological HR spikes or drops, implausible respiratory values, and sustained flat-lining inconsistent with reported work patterns. Artifactual segments were flagged and removed. All data were exported to an Excel spreadsheet.

Statistical analyses were conducted using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA). Quantitative variables such as HR, RR, G-force, and MAP were analyzed as continuous measures; call priority and operational phase were modeled as categorical predictors, and no additional categorization of continuous variables was applied. Mixed effects models specified random intercepts for paramedics and, where applicable, for shifts nested within paramedics, with fixed effects for call priority, operational phase, and selected covariates (e.g., body mass index) and are reported elsewhere (MacQuarrie, 2019).

Methodological Endpoints

Primary methodological endpoints were:

1. Feasibility and adherence: recruitment and retention, monitored shifts per participant, proportion of rostered shifts successfully instrumented.
2. Data quality: proportion of biometric data flagged as artifactual and proportion of shifts meeting the > 75% completeness threshold.
3. Field validity: concordance of Hexoskin heart and respiratory rate patterns with laboratory validation statistics and evidence of expected physiologic gradients across call priority and operational epochs.

Descriptive statistics summarized feasibility and data quality, and field data were interpreted against published laboratory Bland-Altman and intraclass correlation coefficients for Hexoskin. As exemplar analyses to demonstrate analytic capacity, mixed-effects models were used to illustrate within- and between-paramedic variation in HR, RR, and MAP across phases and priorities, adjusting for selected covariates; these were not treated as definitive inferential findings.

To minimize measurement bias, we applied predefined artifact-detection criteria in Vivosense and interpreted field measures in the context of laboratory validation data. Selection bias was mitigated by workforce-aligned sampling; residual selection and Hawthorne effects are considered in the Limitations section.

A completed STROBE checklist is available on request.

ETHICS

Ethical approval was granted by the university Human Research Ethics Committee and the ambulance service Human Research Ethics Committee, and all participants provided written informed consent. Data was deidentified before analysis, with linkage keys held securely by the ambulance service. External funding was not used to support this work.

RESULTS

Results are presented to demonstrate protocol feasibility and operational performance, including recruitment and adherence, shift and call capture, data completeness, artifact rates, and successful linkage of biometric and CAD-derived data streams.

Feasibility and adherence: The protocol achieved high operational feasibility. Across 32 paramedics, the protocol captured 232 monitored routine rostered shifts, comprising approximately 2,700 hours of monitoring and 918 CAD-linked (emergency/000-generated emergency) incidents

Across 232 monitored shifts, paramedics attended a mean of 4.9 ± 1.9 emergency calls and 3.3 ± 1.8 patient transports per shift, with only 4 shifts (2%) recording no emergency calls. Mean time on calls was 4.4 ± 2.4 hours per 12-hour shift, higher in metropolitan paramedics (5.0 ± 2.6 hours) than regional paramedics (3.9 ± 2.0 hours), while the number of transports per shift was similar by posting. There was no loss to follow-up among participants (Table 1). Most rostered monitoring opportunities proceeded as planned, and reasons for non-monitoring (e.g., unplanned leave, equipment logistics) were documented in shift logs.

Measure	Metropolitan (n = 16)	Regional (n = 16)	All Paramedics (n = 32)
Age (years)	35.6 (10.1)	41.0 (6.7)	38.3 (8.8)
Sex (male/female)	10/6	11/5	21/11
Years of service	11.1 (7.4)	11.6 (6.7)	11.3 (6.9)
Years at current level	4.5 (4.0)	7.8 (6.6)	6.2 (5.6)

Table 1. Demographic and occupational characteristics of paramedics.
Note: Values are mean (SD) except sex, where numbers reported are male/female.

Data quality: Physiologic data quality was acceptable within routine operations. Across shifts, approximately 5% of biometric data were flagged as artifactual and removed, with the most significant artifact burden during high-movement epochs, such as en route and on scene. Applying a prespecified 75% completeness threshold at the shift level, most monitored shifts were retained for primary analyses. CAD timestamps and Hexoskin data were successfully merged for all shifts with valid device files, yielding 918 calls with complete epoch-level biometric and operational data (Table 2).

Field validity: Field biometric profiles were consistent with prior laboratory validation and demonstrated the protocol's sensitivity to operational context (Table 3).

Aspect	Indicator	Value (n, % or description)
Shift-level inclusion	Monitored shifts	232 shifts from 32 paramedics
	Shifts with no emergency calls	4/232 (2%)
	Shifts meeting ≥ 75% usable-data threshold	228
Call-level inclusion	Emergency calls with linked biometrics and CAD	918 calls with successfully merged records
Artifact proportion	Overall biometric artifact	Approximately 5% of the physiological data was flagged and removed
	Artifact pattern by phase	Highest during high-movement epochs (en route, on scene) due to torso movement and electrode displacement
Completeness of specific measures	Hexoskin HR, RR and G-force	Available for all shifts meeting the completeness threshold
	BP recordings	Pre- and post-shift BP is highly complete; within-shift post-call BP is more frequently missing during high call volume.
	RPE recordings	Shift-start and end RPE are highly complete; within-call RPE is occasionally missing when operational tempo precluded recording.
Data linkage	Success of Hexoskin–CAD linkage	CAD timestamps successfully merged with Hexoskin for all shifts with valid device files
	Exclusions for device failure	One instance of a participant who was unable to upload shift data but later succeeded.

Table 2. Data completeness, artifact profile and linkage performance.

Domain	Indicator	Value (mean ± SD or n, %)
Shift-level feasibility	Shifts with > 0 emergency calls	228/232 (98%)
	Time on calls per shift (hours)	4.4 ± 2.4 (metro 5.0 ± 2.6; regional 3.9 ± 2.0)
	Proportion of shift time on calls	~37% (higher in metropolitan)
Call-level context	Total emergency calls recorded	918 calls across monitored shifts
	Calls per shift	4.9 ± 1.9 (metro 5.3 ± 1.6; regional 4.5 ± 2.1)
	Transport per shift	3.3 ± 1.8 (metro 3.2 ± 1.7; regional 3.3 ± 1.7)
	Priority-1 calls	20/918 (2%); 17 confirmed cardiac arrests
Biometric field performance	Shift-average heart rate (bpm)	80.6 ± 10.3 (metro 80.8 ± 10.7; regional 80.4 ± 10.1)
	Call-average heart rate (bpm)	76.1 ± 16.3
	Call-maximum heart rate (bpm)	87.3 ± 15.2
	Shift-average respiratory rate (breaths min^{-1})	14.6 ± 3.3
	Call-average respiratory rate (breaths min^{-1})	21.2 ± 5.9
Occupational physical activity	Mean shift G-force (g)	0.09 ± 0.15 (Very Low–Low range)
	Mean call G-force (g)	0.11 ± 0.07
	Mean call-maximum G-force (g)	0.36 ± 0.12
	Steps per 12-hour shift	4,368 ± 1,555 (metro 4,230 ± 1,560; regional 4,469 ± 1,549)

Table 3. Protocol feasibility, call characteristics and biometric performance.
Note: Metro = metropolitan posting; regional = regional posting.

This methodological observational study was reported in accordance with the STROBE guideline for observational studies and with emerging EQUATOR guidance for methodological research.

DISCUSSION

This methodological study demonstrates that a multi-modal protocol integrating wearable biometrics, self-reported workload, and CAD data can be implemented within routine paramedic operations with high adherence and acceptable data quality. By specifying recruitment, device workflows, data processing rules, and hierarchical data structures, the protocol addresses a call for more transparent reporting of complex exposure measurement designs in paramedicine.

Key strengths include workforce-aligned sampling, the integration of validated biometric, BP, and RPE measures with CAD-derived operational epochs, and an explicit framework for artifact handling and completeness. The resulting hierarchical, epoch-based structure preserves operational context and supports multilevel modeling of physiologic responses to paramedic work.

Our finding that multi-modal monitoring was feasible within routine operations, but required close collaboration with clinical and technical stakeholders, mirrors experience in emergency department and first responder settings, where deployment of wireless biosensor systems has depended on careful integration with workflows and infrastructure (Miller et al., 2021).

Limitations include implementation within a single jurisdiction, reliance on a specific wearable platform and analytical software, and the expertise required to manage multi-modal time-series data, which may constrain uptake. Ecological validity remains bounded by the characteristics of a single ambulance service, one wearable platform, and the participating jurisdiction's rostering and case-mix profile

Within a shift, BP and RPE measures were more often missing during periods of high call volume, underscoring trade-offs between measurement intensity and operational burden. Although the protocol may be adaptable to other ambulance and emergency-service contexts, transferability is likely to depend on local rostering models, case mix, device availability, data-governance arrangements, and analytic capabilities.

Implications: Beyond paramedicine, the growing occupational health literature highlights that wearable sensor systems can improve exposure assessment precision and enable continuous monitoring of biomechanical and physiologic loads in real-world work settings, but they also face challenges around sensor placement, data processing, and user acceptance (Babangida et al., 2025). The protocol provides a template for occupational exposure research in other emergency services and shift working groups, where linking biometric and operational data is increasingly feasible. Embedding similar methodological frameworks in future etiologic and intervention studies may help standardize exposure measurement, improve reproducibility, and reduce research waste in paramedicine.

Future work should extend this approach to multi-service, multi-device cohorts and examine how protocol performance varies across organizational contexts.

CONCLUSION

This methodology article presents a replicable, EQUATOR-aligned protocol for integrating wearable biosensors, subjective workload ratings, and CAD data into paramedic occupational exposure research. Taken together, these findings address the study objective by showing that a multi-modal, shift-level monitoring protocol can be implemented within routine paramedic operations with acceptable completeness, manageable artifact rates, and successful integration of biometric and operational data. In conclusion, the principal contribution of this work is methodological: it provides a transparent and replicable framework for future occupational exposure research in paramedicine. It may help to inform health and wellness initiatives in ambulance services.

Conflicts of interest: The authors declare no conflicts of interest related to this study. The mention of specific devices, software, or manufacturers is for methodological transparency only and does not imply endorsement or a financial relationship.

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RESEARCH REPORTS

IMPACT OF A NATIONWIDE NOTIFICATION PROMOTING EARLY ADRENALINE ADMINISTRATION ON TIME TO FIRST ADRENALINE IN OUT-OF-HOSPITAL CARDIAC ARREST IN JAPAN: AN INTERRUPTED TIME-SERIES ANALYSIS

Koshi Nakagawa, PhD, EMT-P*[1,2]; Ryu Kimura[1]; Ryo Sagisaka[2,3]; Daigo Morioka[4]; Hideharu Tanaka[1,2,3]

Author Affiliations: 1. Department of Sport and Medical Science, Kokushikan University, Tama City, Tokyo, Japan; 2. Graduate School of Emergency Medical System, Kokushikan University, Tama City, Tokyo, Japan; 3. Research Institute of Disaster Management and Emergency Medical System, Kokushikan University, Tama City, Tokyo, Japan; 4. School of Health Science and Medical Care, Meiji University of Integrative Medicine, Nantan City, Kyoto, Japan.

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**Corresponding Author:* koshi.n@kokushikan.ac.jp

ABSTRACT

Purpose: This study evaluated whether the March 30, 2017, nationwide notification from the Fire and Disaster Management Agency (FDMA) shortened the time from patient contact to adrenaline administration (adrenaline time) for out-of-hospital cardiac arrest (OHCA).

Methods: We conducted an interrupted time-series (ITS) analysis using data from the All-Japan Utstein Registry (January 1, 2010-April 26, 2020). The study included OHCA patients who received adrenaline, with adrenaline time as the primary outcome. We estimated the immediate level change and post-intervention slope change, stratified by shockable and non-shockable rhythms. Ninety-five percent confidence intervals (CIs) and p values were Bonferroni-adjusted for the coprimary endpoints (level and slope change).

Results: We analyzed 18,412 patients in the shockable group and 160,013 in the non-shockable group. For the shockable group, the notification was not associated with a statistically significant level change (.19 minutes; 95% CI_{adj} [-0.33, 0.71]; p_{adj} = .81) or slope change (-0.01 minutes/30-day; 95% CI_{adj} [-0.03, 0.01]; p_{adj} = .38). Similarly, for the non-shockable group, no significant level change (-0.09 minutes; 95% CI_{adj} [-0.30, .11]; p_{adj} = .59) or slope change (-0.01 minutes/30-day; 95% CI_{adj}, [-0.02, 0.00]; p_{adj} = .10) was observed.

Conclusion: The FDMA notification was not associated with an immediate or long-term reduction in adrenaline time, a clinically relevant prehospital process measure on the causal path to better outcomes.

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) affects approximately 130,000 people annually in Japan (Fire and Disaster Management Agency, 2020a). As in other countries, OHCA remains an important public health challenge (Berdowski et al., 2010). In Japan's prehospital emergency care, intravenous adrenaline administration by emergency life-saving technicians (ELSTs) is standard

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practice (Japan Resuscitation Council, 2016, 2021). A large randomized controlled trial and its long-term follow-up showed that adrenaline increased the return of spontaneous circulation and survival to hospital discharge but did not clearly improve favorable neurological outcomes (Haywood et al., 2021; Perkins et al., 2018). In recent years, it has been suggested that the timing of adrenaline administration, in addition to whether it is administered, can affect outcomes, with some reports indicating that early administration is associated with improved survival and favorable neurological outcomes (Okubo et al., 2021; Ran et al., 2020).

The Japan Resuscitation Council (JRC) Guidelines 2015 were the first to address the timing of adrenaline administration, recommending it as early as possible for non-shockable rhythms and proposing adrenaline administration for shockable rhythms after unsuccessful defibrillation (Japan Resuscitation Council, 2016). On March 30, 2017, the Fire and Disaster Management Agency (FDMA) issued a nationwide notification (FDMA Notification No. 41) as non-binding "technical advice" under Article 37 of the Fire Organization Act (Fire and Disaster Management Agency, 2017). Consistent with the JRC Guidelines 2015, it encouraged adrenaline administration as early as possible after patient contact in non-shockable cases; operational protocols were left to regional medical control (MC) councils, and no nationally mandated numerical time targets were specified. However, the extent to which this policy intervention shortened the time to adrenaline administration nationwide has not been systematically evaluated.

Earlier adrenaline is associated with improved survival and neurological outcomes (Nakagawa et al., 2023; Okubo et al., 2021; Ran et al., 2020), and shortening the time to adrenaline is a recognized quality goal; whether a national policy can achieve this has not been tested. In what is, to our knowledge, the first nationwide interrupted time-series evaluation of this policy, we therefore addressed a single question: Did the 2017 FDMA notification reduce the time from patient contact to first adrenaline administration (adrenaline time) nationwide? The study focused on whether the policy made prognosis-relevant early adrenaline achievable in practice rather than on patient prognosis itself; its outcome is a prehospital process measure (adrenaline time) not survival, and a rigorously estimated result—positive or null—informs how such policies should be designed.

METHODS

Study Design

This observational study used an interrupted time-series (ITS) design with data from the All-Japan Utstein Registry. This study was designed and analyzed using established recommendations for interrupted time-series and segmented-regression analyses (Jandoc et al., 2015; Lopez Bernal et al., 2017; Penfold & Zhang, 2013; Wagner et al., 2002).

This study was approved by the Chuo University Ethics Committee (approval number 2025-076). The requirement for individual informed consent was waived because the study used de-identified registry data.

Study Setting

As of 2020, Japan had a population of approximately 126 million and an area of 378,000 km . In Japan, emergency medical services (EMS) are provided around the clock by fire

departments (Okada et al., 2024). The system is single-tiered, with ambulances typically staffed by three emergency medical technicians (EMTs), at least one of whom is an ELST. Under the online medical direction of a physician, ELSTs are authorized to perform advanced life support (ALS) procedures such as establishing intravenous access, adrenaline administration, and advanced airway management (AAM) (e.g., supraglottic airway or endotracheal intubation). Within this scope, adrenaline is the only resuscitation drug that ELSTs are authorized to administer; antiarrhythmic agents are not legally authorized for administration by ELSTs, and physician-staffed ALS cases were excluded, so antiarrhythmic administration is structurally absent from this cohort. As a general rule, ELSTs administer adrenaline to cardiac-arrest patients aged 8 years or older, at a fixed dose of 1 mg irrespective of age or body weight; a small number of younger patients may receive adrenaline under exceptional circumstances (for example, when intravenous access has already been established), and all such cases were retained in the analysis. Adrenaline is administered intravenously using a 1-mg prefilled syringe, with repeat doses of 1 mg every 3-5 minutes. Although early adrenaline administration is a fundamental principle, transport to a medical facility may be prioritized over on-scene treatment depending on environmental factors and the estimated transport time. Consequently, adrenaline is sometimes not administered at the scene or is administered during transport to the hospital (e.g., inside an ambulance).

The intervention evaluated in this study was FDMA Notification No. 41, issued on March 30, 2017. It was distributed to fire departments nationwide as "technical advice" under Article 37 of the Fire Organization Act—an advisory instrument rather than a binding directive. In line with the JRC Guidelines 2015, the notification recommended earlier adrenaline administration for non-shockable rhythms; for shockable rhythms, adrenaline continued to follow unsuccessful defibrillation (approximately two minutes after the shock). Because the notification delegated implementation to regional MC councils and set no nationwide numerical time targets, its intensity and uniformity of implementation likely varied across regions—a feature central to interpreting our findings.

On April 27, 2020, the FDMA issued a nationwide notification to fire departments titled "Guidelines for the Response of Fire Departments to Patients with Cardiopulmonary Arrest Associated with Coronavirus Disease 2019 (COVID-19)" (Fire and Disaster Management Agency, 2020b). In addition to enforcing standard precautions, these guidelines emphasized infection-control measures for aerosol-generating resuscitation procedures and noted that early instrumented airway management (AAM) was desirable when it could be performed rapidly and reliably to minimize air leakage from patient exhalation. Because this may have increased the number of cases in which AAM was prioritized over adrenaline administration, this study used data from before the guidelines were issued.

In Japan, EMS personnel are typically not authorized to terminate resuscitation at the scene; thus, all patients for whom resuscitation is attempted are transported to the hospital. However, resuscitation attempts are not initiated in conditions such as severe torso trauma, traumatic brain injury with severe cerebral prolapse, skeletal remains, or early postmortem changes.

The ALS protocol in Japan is based on JRC guidelines, which are in accordance with the International Liaison Committee on Resuscitation Consensus. Furthermore, based on the

JRC guidelines, the FDMA notifies fire departments nationwide about its EMS protocols, allowing regional departments to establish their own protocols tailored to their local medical systems.

Study Participants

This study included patients with OHCA who were treated between January 1, 2010 and April 26, 2020 and received prehospital adrenaline. The exclusion criteria were: (1) receipt of physician-administered ALS, (2) EMS-witnessed cardiac arrest, (3) missing dispatcher-assistance data, (4) an unknown initial electrocardiogram (ECG) rhythm, (5) an adrenaline time of < 0 or > 40 minutes, and (6) a response time (emergency call to patient contact) of < 0 or > 20 minutes. Because the timing of adrenaline administration differs according to the initial ECG rhythm, the patients were divided into shockable and non-shockable groups, and each group was analyzed separately.

Data Collection and Quality Control

The All-Japan Utstein Registry, a nationwide OHCA registry, was established by the FDMA in January 2005. The registry records data in the international Utstein style. Utstein-style variables have been described previously (Jacobs et al., 2004; Okada et al., 2024). Time-related data were recorded by EMS personnel at the scene and compiled into a registry. These data included the times of emergency calls, ambulance dispatch, arrival at the scene, patient contact, adrenaline administration, and hospital arrival. The data were recorded in minutes (min).

Outcome

The primary outcome was the adrenaline time (min), defined as the interval from EMS patient contact to the first prehospital adrenaline administration.

Statistical Analysis

Because the timing and role of adrenaline differ fundamentally by initial rhythm—adrenaline is given as early as possible for non-shockable rhythms but only after unsuccessful defibrillation for shockable rhythms—all analyses were pre-specified to stratify by initial rhythm, modeling the shockable and non-shockable groups separately. We then summarized patient characteristics for the pre-intervention (January 1, 2010, to March 29, 2017) and post-intervention (March 30, 2017, to April 26, 2020) periods within each group. Categorical variables were presented as counts (percentages) and continuous variables as means (standard deviations). Imbalances between groups were assessed using the standardized mean difference (SMD).

In the ITS analysis, we defined the intervention date (March 30, 2017) as day 0. We then aggregated the data into 30-day intervals using the mean adrenaline time for each interval as a single time-series observation. An ITS segmented regression model was applied separately to the shockable and non-shockable rhythm groups to estimate the immediate-level and post-intervention slope changes associated with the intervention.

To assess the plausibility of the ITS design assumptions, we prospectively examined three conditions: (1) the assignment rule and threshold were clear, (2) the assignment variable (calendar date) was not subject to arbitrary manipulation, and (3) the assign-

ment variable did not affect other factors related to the outcome (Kontopantelis et al., 2015). Condition 1 was satisfied because the intervention date could be uniquely defined. Regarding condition 2, the intervention was a policy change based on a notification from the FDMA, making it practically impossible for providers in the field to manipulate the assignment variable. For condition 3, we tested for discontinuities at the intervention point by replacing the primary outcome in the ITS model with baseline covariates potentially associated with adrenaline time. These covariates included the day and time of OHCA onset, age, sex, etiology of arrest, witness status, bystander cardiopulmonary resuscitation (BCPR), public-access defibrillation (PAD), dispatcher assistance, EMS defibrillation, AAM before adrenaline administration, and response time. Only covariates that showed potential discontinuity were included in the final adjusted ITS model.

To account for seasonality, we compared a model with no harmonic terms to models with harmonic terms (k = 1-4), assuming a 12-month cycle (Lopez Bernal et al., 2017). The final model for each group was selected using the Bayesian Information Criterion (BIC), which penalizes model complexity to avoid overfitting. Consequently, we adopted a model with k = 1 for the shockable group and k = 2 for the non-shockable group.

The effect of the intervention was estimated from the ITS models by calculating partial regression coefficients, Bonferroni-adjusted 95% confidence intervals (CIs), and Bonferroni-adjusted p-values. Because both level and slope changes were considered primary endpoints, we applied the Bonferroni method to adjust the significance level ($\alpha = 0.05/2 = 0.025$), controlling Type I error inflation from multiple comparisons.

Furthermore, we visualized the trend of the 30-day mean adrenaline time on a relative time axis. The observed 30-day averages are plotted as points in the figures. These points are overlaid with the fitted trend (solid line) and Bonferroni-adjusted 95% CI derived from the final ITS model. Additionally, the counterfactual trajectory, assuming the pre-intervention trend would have continued without the intervention, was extrapolated into the post-intervention period and displayed as a red dashed line with its corresponding 95% CI.

We conducted three sensitivity analyses to assess the robustness of the primary findings. First, we repeated the primary ITS analysis after excluding the initial 6 months following the intervention date. This accounts for a possible phased rollout of policies across different medical control (MC) regions. Second, we performed an ITS analysis with the pre-intervention period restricted to either the 24 or 36 months immediately preceding the intervention to evaluate the influence of long-term pre-intervention data on our estimates. Third, we conducted the primary analysis after excluding all data later than December 31, 2019—around the time the first COVID-19 cases were reported to the World Health Organization—to assess the potential impact of pandemic-related changes in the EMS system and operational procedures (World Health Organization, 2020). In all sensitivity analyses, we applied the same ITS model as in the primary analysis, with level and slope changes as endpoints.

Autocorrelation function plots of the residuals from our primary models showed no evidence of significant autocorrelation. The residuals satisfied the normality assumption. All statistical analyses were performed using R version 4.5.1 (R Foundation for Statistical Computing, Vienna, Austria). The significance level was set at .05 (two-tailed).

RESULTS

Figure 1 shows the patient selection flowchart. Of the 1,254,273 OHCA cases registered during the study period, 229,298 received adrenaline. After applying all eligibility criteria, 178,425 patients were included in the final analysis. This cohort consisted of 18,412 patients in the shockable rhythm group (pre-intervention, *n* = 12,514; post-intervention, *n* = 5,898) and 160,013 patients in the non-shockable rhythm group (pre-intervention, *n* = 94,507; post-intervention, *n* = 65,506).

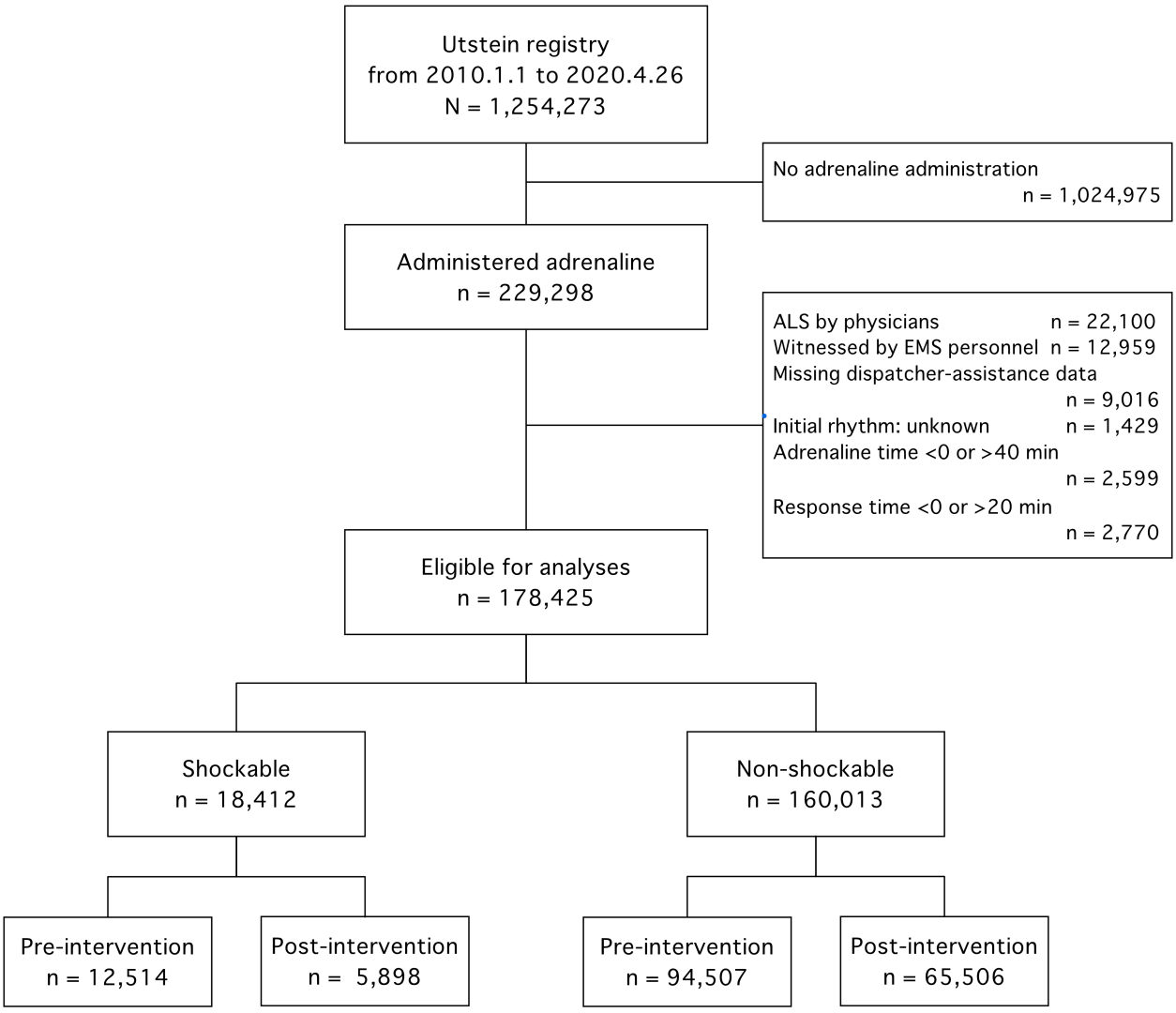


Figure 1. Patient selection flowchart.
Abbreviations: ALS, advanced life support; EMS, emergency medical service.)

Patient characteristics are summarized in Table 1. In the shockable rhythm group, the mean patient age was 67.1 years, and 80.0% were male. The age distribution was overwhelmingly adult: the median age was 69 years (interquartile range [IQR], 58-78; range, 8-105), and pediatric patients (< 16 years) accounted for only 0.1%. Bystander CPR (62.8% vs. 55.6%; SMD = 0.15), dispatcher assistance (68.1% vs. 58.9%; SMD = 0.19), and defibrillation by EMS (98.2% vs. 95.5%; SMD = 0.17) were all more frequent in the post-intervention period, as was AAM before adrenaline administration (50.1% vs. 36.7%; SMD = 0.27).

The mean response time was slightly longer in the post-intervention period (8.0 vs. 7.7 min; SMD = 0.10), whereas the mean time to adrenaline administration was longer in the pre-intervention period (14.2 vs. 13.5 min; SMD = 0.12).

Characteristic	Shockable				Non-Shockable			
	Overall	Pre-Intervention	Post-Intervention	SMD	Overall	Pre-Intervention	Post-Intervention	SMD
n (%)	*n* = 18,412	*n* = 12,514	*n* = 5,898		*n* = 160,013	*n* = 94,507	*n* = 65,506	
Occurrence date				0.006				0.004
Weekday	12,904 (70.1)	8,759 (70.0)	4,145 (70.3)		112,999 (70.6)	66,670 (70.5)	46,329 (70.7)	
Weekend	5,508 (29.9)	3,755 (30.0)	1,753 (29.7)		47,014 (29.4)	27,837 (29.5)	19,177 (29.3)	
Occurrence time frame				0.01				0.02
Daytime	8,389 (45.6)	5,689 (45.5)	2,700 (45.8)		68,145 (42.6)	40,674 (43.0)	27,471 (41.9)	
Nighttime	10,023 (54.4)	6,825 (54.5)	3,198 (54.2)		91,868 (57.4)	53,833 (57.0)	38,035 (58.1)	
Age, mean (SD), y	67.1 (15.2)	66.9 (15.3)	67.5 (15.1)	0.04	76.3 (14.6)	75.9 (14.8)	76.9 (14.3)	0.07
Age, median [IQR] (range), y	69 [58–78] (8–105)	68 [58–78] (8–103)	69 [58–79] (9–105)		80 [70–86] (0–110)	79 [69–86] (0–107)	80 [70–87] (0–110)	
Age group, n (%)				0.05				0.07
<16 y	19 (0.1)	16 (0.1)	3 (0.1)		217 (0.1)	138 (0.1)	79 (0.1)	
16–64 y	7,069 (38.4)	4,879 (39.0)	2,190 (37.1)		27,165 (17.0)	17,015 (18.0)	10,150 (15.5)	
≥65 y	11,324 (61.5)	7,619 (60.9)	3,705 (62.8)		132,631 (82.9)	77,354 (81.9)	55,277 (84.4)	
Sex, male	14,728 (80.0)	10,004 (79.9)	4,724 (80.1)	0.004	94,279 (58.9)	55,765 (59.0)	38,514 (58.8)	0.004
Cardiogenic	16,626 (90.3)	11,215 (89.6)	5,411 (91.7)	0.07	98,440 (61.5)	56,924 (60.2)	41,516 (63.4)	0.07
Witnessed	4,631 (25.2)	3,168 (25.3)	1,463 (24.8)	0.002	27,298 (17.1)	16,686 (17.7)	10,612 (16.2)	0.04
Bystander CPR performed	10,660 (57.9)	6,958 (55.6)	3,702 (62.8)	0.15	86,803 (54.2)	49,219 (52.1)	37,584 (57.4)	0.11
Public access defibrillation	794 (4.3)	523 (4.2)	271 (4.6)	0.02	1,885 (1.2)	1,101 (1.2)	784 (1.2)	0.003
Dispatcher-assistance	11,391 (61.9)	7,375 (58.9)	4,016 (68.1)	0.19	101,913 (63.7)	57,852 (61.2)	44,061 (67.3)	0.13
Defibrillation by EMS	17,746 (96.4)	11,952 (95.5)	5,794 (98.2)	0.17	11,934 (7.5)	7,389 (7.8)	4,545 (6.9)	0.02
AAM before adrenaline administration	7,548 (41.0)	4,594 (36.7)	2,954 (50.1)	0.27	78,649 (49.2)	41,596 (44.0)	37,053 (56.6)	0.25
Response time, mean (SD), min	7.8 (2.8)	7.7 (2.8)	8.0 (2.7)	0.10	8.0 (2.9)	7.9 (2.9)	8.1 (2.9)	0.07
Time from EMS contact to adrenarine administration, mean (SD), min	14.0 (6.3)	14.2 (6.4)	13.5 (6.1)	0.12	14.9 (6.5)	15.1 (6.7)	14.4 (6.3)	0.11

Table 1. Baseline patients' characteristics stratified by initial rhythm and pre-/post-intervention periods.
Notes: Pre-intervention: cardiac arrests before the FDMA notification (2010-01-01 to 2017-03-29). Post-intervention: on/after the notification (2017-03-30 to 2020-04-26). Data are n (%) unless otherwise indicated.
Abbreviations: SMD, standardized mean difference between pre- and post-intervention groups (continuous variables: standardized difference of means; the age-group categorical SMD uses the multinomial [Yang–Dalton] method). SD, standard deviation; IQR, interquartile range; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; AAM, advanced airway management.

In the non-shockable rhythm group, the mean patient age was 76.3 years, and 58.9% were male. The median age was 80 years (IQR, 70-86; range, 0-110), and pediatric patients (< 16 years) accounted for 0.1% of the group. Bystander CPR (57.4% vs. 52.1%; SMD = 0.11), dispatcher assistance (67.3% vs. 61.2%; SMD = 0.13), and AAM before adrenaline administration (56.6% vs. 44.0%; SMD = 0.25) were all more frequent in the post-intervention period.

As in the shockable group, the mean time to adrenaline administration was longer in the pre-intervention period (15.1 vs. 14.4 min; SMD = 0.11).

Table 2 shows the assessment of discontinuities in baseline covariates at the intervention point. In the shockable group, a significant discontinuity was observed in the proportion of patients receiving AAM before adrenaline administration (coefficient [95% CI], 0.04 [0.01, 0.07], p = .02). In the non-shockable group, significant discontinuities were identified in witness status (coefficient [95% CI], -0.03 [-0.04, -0.02], p < .001) and response time (coefficient [95% CI], 0.08 [0.02, 0.14], p = 0.01). Therefore, these variables were included in the final ITS model for adjustment.

	Shockable			Non-Shockable		
Variable	**Coefficient**	**95% CI**	***p*-value**	**Coefficient**	**95% CI**	***p*-value**
Occurrence date	-0.02	(-0.05 to 0.01)	0.13	0.01	(-0.00 to 0.02)	0.19
Occurrence time frame	0.02	(-0.01 to 0.05)	0.19	-0.01	(-0.02 to 0.00)	0.08
Age	0.72	(-0.23 to 1.68)	0.14	-0.06	(-0.36 to 0.24)	0.68
Sex	-0.02	(-0.04 to 0.01)	0.12	0.00	(-0.01 to 0.01)	0.50
Cardiogenic	0.01	(-0.01 to 0.02)	0.50	0.01	(-0.00 to 0.02)	0.21
Witness status	-0.02	(-0.05 to 0.01)	0.20	-0.03	(-0.04 to -0.02)	<.001
Bystander CPR performed	0.00	(-0.03 to 0.03)	0.90	0.00	(-0.01 to 0.01)	0.93
Public access defibrillation	0.00	(-0.02 to 0.01)	0.79	0.00	(-0.00 to 0.00)	0.88
Dispatcher-assistance	0.02	(-0.01 to 0.05)	0.30	0.00	(-0.01 to 0.01)	0.63
Defibrillation by EMS	0.00	(-0.01 to 0.00)	0.31	0.00	(-0.01 to 0.00)	0.35
AAM before adrenaline administration	0.04	(0.01 to 0.07)	0.02	-0.01	(-0.02 to 0.00)	0.09
Response time	0.09	(-0.08 to 0.27)	0.31	0.08	(0.02 to 0.14)	0.01

Table 2. Validity check of the interrupted time-series design: assessment of discontinuities in baseline covariates at the intervention point.

Note: This analysis was a necessary step to identify which baseline covariates required adjustment—only covariates showing a discontinuity were included in the adjusted model—and it does not estimate the intervention effect on adrenaline time, which is reported in Table 3. Each baseline covariate was substituted as the outcome to test for a level discontinuity at the intervention date.

Abbreviation: CI, confidence interval; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; AAM, advanced airway management.

The results of the primary ITS models are presented in Table 3 and illustrated in Figure 2. In the shockable group, no statistically significant immediate level change (0.19; 95% CI_{adj} [-0.33, 0.71]; p_{adj} = .81) or subsequent slope change (-0.01; 95% CI_{adj} [-0.03, 0.01]; p_{adj} = .38) was observed following the intervention. Similarly, in the non-shockable group, no significant changes were observed for either the level (-0.09; 95% CI_{adj} [-0.30, 0.11]; p_{adj} = .59) or the slope (-0.01; 95% CI_{adj} [-0.02, 0.00]; p_{adj} = .10).

The three sensitivity analyses are presented in Table 4. In the model excluding the initial 6 months post-intervention, the estimated level change for the shockable group was -0.16 (95% CI_{adj} [-0.69, 0.37]; p_{adj} = 1.00). Although not statistically significant, the direction of this effect differs from that in the primary model. For the non-shockable group, however, this analysis showed a statistically significant level change of -0.35 (95% CI_{adj} [-0.59, -0.10]; p_{adj} = .004). The remaining sensitivity analyses showed no statistically significant associations.

	Shockable[a]			Non-Shockable[b]		
	Coefficient	Bonferroni adj. 95 % CI[c]	Bonferroni adj. *p*[c]	Coefficient	Bonferroni adj. 95 % CI[c]	Bonferroni adj. *p*[c]
Level change	0.19	-0.33 to 0.71	0.81	-0.09	-0.30 to 0.11	0.59
Slope change	-0.01	-0.03 to 0.01	0.38	-0.01	-0.02 to 0.00	0.10

Table 3. Interrupted time-series model estimates of the level and slope changes in adrenaline time.
[a] *Shockable: pre-intervention intercept = 14.7, pre-intervention slope = -0.01, post-intervention slope = -0.02. Covariates: advanced airway management before adrenaline administration. Seasonality modeled by harmonic regression (12-month period, 1 harmonic). No multicollinearity among variables.*
[b] *Non-shockable: pre-intervention intercept = 13.2, pre-intervention slope = -0.01, post-intervention slope = -0.02. Covariates: witness status and response time. Seasonality modeled by harmonic regression (12-month period, 2 harmonics). No multicollinearity among variables*
[c] *Bonferroni correction applied for the two primary comparisons (α = 0.025). CI, confidence interval.*

DISCUSSION

This study employed an ITS design with the All-Japan Utstein Registry to analyze changes in adrenaline time following the March 30, 2017, notification from the FDMA. Our results demonstrated no statistically significant immediate level change or post-intervention slope change. The significant level change in the non-shockable group, seen only after excluding the first 6 months (-0.35 min), suggests that the policy's effects may become apparent only after a phased implementation period. However, these findings suggest that any changes had limited clinical significance.

The FDMA notification likely failed to reduce adrenaline administration time nationwide because it was a low-intensity policy that granted broad discretion for implementation. As an advisory instrument based on the JRC Guidelines 2015, it relied on regional MC councils to develop operational protocols and lacked specific national targets. Consequently, implementation varied widely by region, likely diluting any local effects on the national average. Framed this way, a rigorously estimated null result is itself an actionable finding: an advisory notification that merely communicates a recommendation on paper—without embedded numerical time targets—did not shorten adrenaline time nationally.

Aichi Prefecture, which has a short adrenaline administration time, uses a specific time-based protocol for adrenaline administration (Aichi Council for the Advancement of Ambulance Services, n.d.; Ueta et al., 2023). This protocol codifies clear temporal goals—such as establishing intravenous access within 4 min of contact, the first adrenaline dose within the next 2 min, AAM within another 2 min, and the second adrenaline dose 2 min later, creating a shared operational standard (Table 5). Our findings suggest that a national notification without process-level details is unlikely to reduce adrenaline time nationwide. Aichi additionally operates its own regional certification system with intensive, standardized crew training, reinforcing these time targets in practice (Kitagawa & Saito, 2018). This implies that achieving a meaningful nationwide reduction requires a more specific policy that defines and embeds temporal goals into practice, supported by training and certification (Ueta et al., 2023). Similar time-target-based quality improvement frameworks have improved time-sensitive care in other emergency conditions (Fonarow et al., 2011).

The primary strength of this study is its quasi-experimental ITS design. This approach allowed us to estimate policy effects using continuous observational data from the

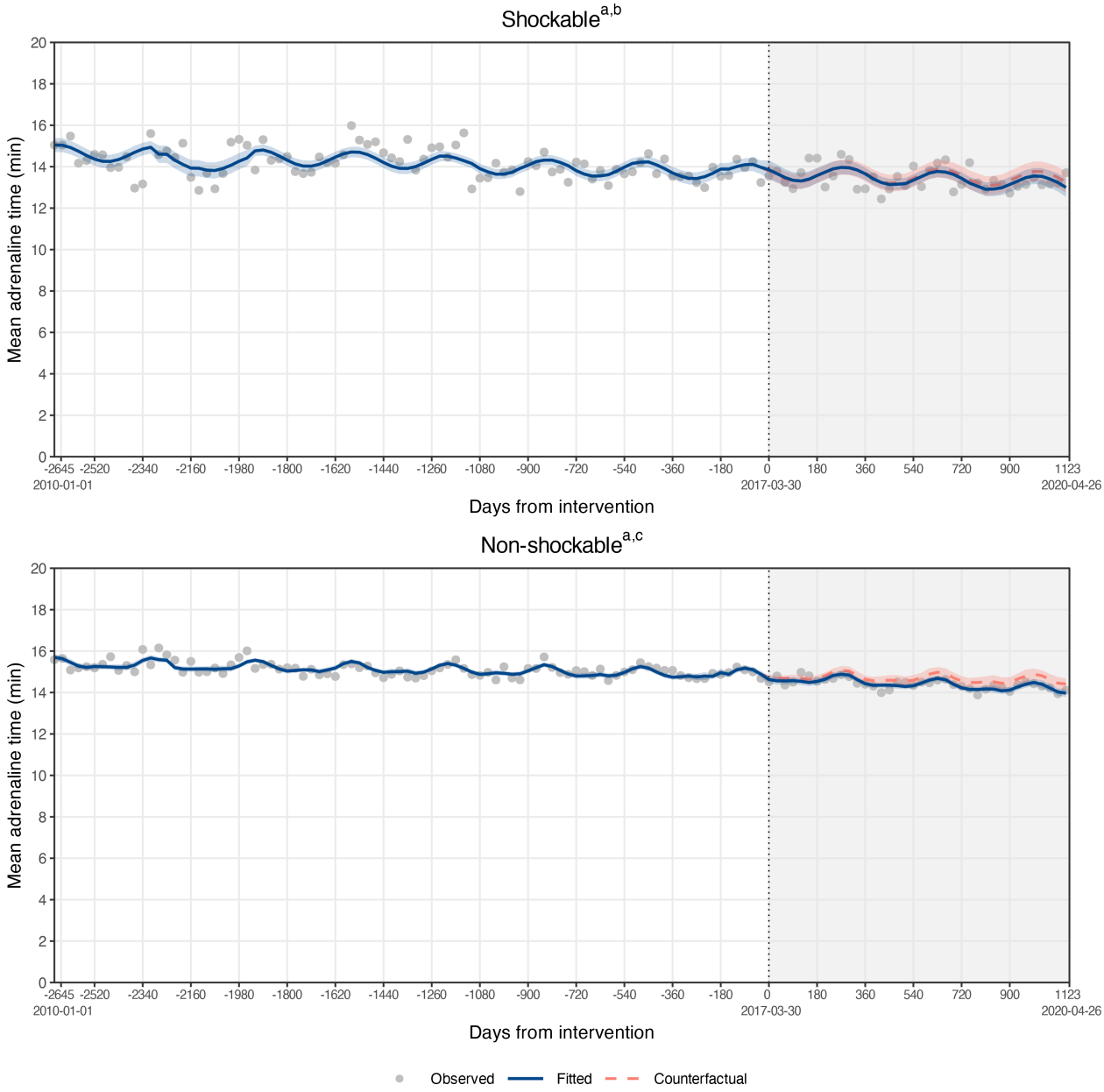


Figure 2. Trends in adrenaline time with interrupted time-series analysis.
Abbreviation: adrenaline time, time from emergency medical service contact to adrenaline administration.
[a] *Bonferroni-adjusted 95% confidence intervals (□ = 0.025 for two primary comparisons).*
[b] *Covariates for shockable group include advanced airway management (AAM) before adrenaline administration; seasonality modeled using harmonic regression (12-month period, 1 harmonic). No multicollinearity was observed.*
[c] *Covariates for non-shockable group include witness status and response time; seasonality modeled using harmonic regression (12-month period, 2 harmonics). No multicollinearity was observed.*

All-Japan Utstein Registry with a clearly defined intervention date (Lopez Bernal et al., 2017; Penfold & Zhang, 2013). The ITS design is a robust method for evaluating policy interventions in which randomization is not feasible. It offers higher internal validity than simple pre-post comparisons because it separates immediate-level changes from post-intervention slope changes (Wagner et al., 2002). Furthermore, its ability to explicitly model pre-intervention trends and seasonality makes it a particularly suitable framework for analyzing nationwide EMS data (Lopez Bernal et al., 2017). Our study adhered to best practices for ITS implementation to ensure the reliability of our findings. We prospec-

tively checked for discontinuities in the baseline covariates at the intervention point. We selected the final model after comparing multiple candidates for seasonality adjustment. These rigorous steps ensure a robust and reliable policy evaluation.

	Shockable			Non-Shockable		
	Coefficient	Bonferroni adj. 95 % CI[a]	Bonferroni adj. *p*[a]	Coefficient	Bonferroni adj. 95 % CI[a]	Bonferroni adj. *p*[a]
Excluding first 6 months post-intervention[b]						
Level change	-0.16	-0.69 to 0.37	1.00	-0.35	-0.59 to -0.10	0.004
Slope change	-0.002	-0.027 to 0.024	1.00	-0.005	-0.016 to 0.006	0.70
Pre-intervention period limited to 24 months[c]						
Level change	0.30	-0.31 to 0.91	0.53	-0.03	-0.23 to 0.16	1.00
Slope change	0.001	-0.035 to 0.036	1.00	0.001	-0.013 to 0.015	1.00
Pre-intervention period limited to 36 months[d]						
Level change	0.13	-0.41 to 0.67	1.00	-0.13	-0.32 to 0.07	0.29
Slope change	-0.01	-0.04 to 0.01	0.47	-0.009	-0.020 to 0.003	0.18
Excluding data after Dec 31, 2019 (before COVID-19)[e]						
Level change	0.20	-0.32 to 0.73	0.79	-0.08	-0.30 to 0.13	0.74
Slope change	-0.01	-0.04 to 0.01	0.50	-0.01	-0.02 to 0.002	0.15

Table 4. Results of sensitivity analyses.

[a] *Bonferroni correction applied for two primary comparisons (α = 0.025).*

[b] *Shockable: Pre-intervention, n = 12,667 (89 points); Post-intervention, n = 4,938 (31 points). Non-shockable: Pre-intervention, n = 95,693 (89 points); Post-intervention, n = 57,423 (31 points).*

[c] *Shockable: Pre-intervention, n = 3,854 (25 points); Post-intervention, n = 5,745 (37 points). Non-shockable: Pre-intervention, n = 31,880 (25 points); Post-intervention, n = 64,320 (37 points).*

[d] *Shockable: Pre-intervention, n = 5,630 (37 points); Post-intervention, n = 5,745 (37 points). Non-shockable: Pre-intervention, n = 45,706 (37 points); Post-intervention, n = 64,320 (37 points).*

[e] *Shockable: Pre-intervention, n = 12,667 (89 points); Post-intervention, n = 5,120 (33 points). Non-shockable: Pre-intervention, n = 95,693 (89 points); Post-intervention, n = 56,309 (33 points).*

Step	Procedure	Target After Preceding Step	Cumulative Time from Contact
1	Secure intravenous (IV) access	Within 4 min of patient contact	≤ 4 min
2	First adrenaline (1 mg) administration	Within the next 2 min	≤ 6 min
3	Advanced airway management (AAM)	Within another 2 min	≤ 8 min
4	Second adrenaline (1 mg) administration	Within the next 2 min	≤ 10 min

Table 5. Time-targeted field protocol for administration used in Aichi Prefecture, Japan.

Note: The protocol codifies sequential time targets, measured from the moment of patient contact, that allow two adrenaline doses to be administered within 10 min in the field. Reproduced from the Aichi Prefecture ambulance cardiopulmonary resuscitation and pre-cardiac-arrest protocols; the same target sequence is described in Ueta et al. (2023).

Abbreviations: AAM, advanced airway management; IV, intravenous. In a nationwide analysis using the All-Japan Utstein Registry, Aichi Prefecture recorded the shortest mean time from patient contact to first adrenaline administration among Japanese prefectures (9.0 ± 4.6 min) and the highest proportion of patients receiving adrenaline within 10 min of contact (75.1%), compared with a national mean of 15.4 ± 6.3 min (Ueta et al., 2023). Crew adherence is reinforced through the prefecture's regional certification and standardized re-education system, administered by the district medical control councils (Kitagawa & Saito, 2018).

Protocol source: Aichi Council for the Advancement of Ambulance Services [Aichi Prefectural Medical Control Council]. (n.d.). Aichi Prefecture ambulance cardiopulmonary resuscitation protocol and pre-cardiac-arrest protocol (16th ed.) [in Japanese]. Nagoya, Japan: The Council. The same four-step target sequence is described in Ueta, H., Tanaka, H., Takyu, H., et al. (2023). Journal of EMS Medicine, 2(1), 31–38. https://doi.org/10.35616/jemsm.2021.00080*. Certification and standardized-training system: Kitagawa, Y., & Saito, H. (2018). Current status of the medical control system in Aichi Prefecture [in Japanese]. FY2018 National Medical Control Council Liaison Conference, Fire and Disaster Management Agency.* https://www.fdma.go.jp/singi_kento/kento/items/kento233_03_shiryo-2.pdf

LIMITATIONS

This study has several limitations. First, because this was an observational study using secondary data from the All-Japan Utstein Registry, the influence of unmeasured confounders could not be completely ruled out. Factors such as the resuscitation skills of the EMTs or specific on-scene circumstances may have influenced the time to adrenaline administration. In particular, the All-Japan Utstein Registry does not record indicators of cardiopulmonary resuscitation quality (e.g., chest compression depth or rate). In addition, although the time to defibrillation is recorded, it is defined only for patients who actually received defibrillation; because most non-shockable arrests—and a minority of shockable arrests—do not, this interval is missing for a large proportion of the cohort, so we did not include it as a covariate to avoid the resulting missing data and selection problems. Residual confounding by these unmeasured or only partially observed process factors cannot be excluded. Second, the ITS design assumes the absence of concurrent events that can systematically affect outcomes (Lopez Bernal et al., 2018). We cannot entirely rule out residual time-varying confounding factors such as nationwide operational changes, equipment updates, or shifts in public behavior regarding emergency calls. Third, our analysis does not estimate regional heterogeneity in policy implementation; our model did not account for potential implementation lags or variations in adherence. Fourth, we modeled seasonality using harmonic terms in the order selected by BIC. Our model may not perfectly capture the underlying seasonal patterns, which may have influenced our estimates (Bhaskaran et al., 2013). Fifth, although aggregating data into 30-day intervals mitigates the influence of weekly variations and outliers, it may mask sharp short-term changes in outcomes (Alarcon Falconi et al., 2020). Sixth, the end of the study period coincided with the beginning of the COVID-19 pandemic and the resulting changes in emergency demand and operational procedures may have affected our estimates (Fire and Disaster Management Agency, 2020b; World Health Organization, 2020). Finally, our findings are specific to the Japanese EMS context (e.g., the scope of practice for ELSTs, the MC system, and the prevalence of dispatcher-assisted CPR and PAD). Therefore, the transportability of the findings to other countries or EMS systems may be limited.

CONCLUSION

Using a nationwide interrupted time-series analysis, we found that the 2017 FDMA notification was not associated with a statistically significant immediate or sustained reduction in adrenaline time for either shockable or non-shockable rhythms. Our conclusions are restricted to this prehospital process measure and make no claim about patient survival. The findings indicate that an advisory notification without embedded temporal targets is insufficient on its own; future efforts should codify explicit time targets at the MC level, together with crew training, implementation support, and procedural refinement.

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RESEARCH REPORTS

LOW-ACUITY CARE IN AUSTRALIAN UNDERGRADUATE PARAMEDICINE LEARNING OUTCOMES

Anthony Carnicelli, BClinPrac(Paramed), GCertL&THthProf, MAdvParamed*[1]; Anne-Marie M. Williams, PhD[1]; Dale G. Edwards, BHlthSci(Paramedic), MEd, EdD[2,3]

Author Affiliations: 1. Tasmanian School of Medicine, University of Tasmania, Hobart, TAS, Australia; 2. School of Paramedicine, University of Tasmania, Hobart, TAS, Australia; 3. School of Nursing, Paramedicine, and Healthcare Sciences, Charles Sturt University, Bathurst, NSW, Australia.

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**Corresponding Author:*
anthony.carnicelli@utas.edu.au

ABSTRACT

Introduction: Low-acuity presentations constitute a substantial proportion of ambulance caseload in Australia. Although emergency care is central to paramedicine education, graduates must also be prepared to assess and make non-conveyance decisions for this patient group. In Australia, undergraduate programs provide the foundation for entry into paramedicine. However, little is known about how low-acuity care is represented within curricula, particularly through subject unit learning outcomes (LOs).

Methods: An exploratory document analysis was conducted utilizing publicly available LOs and unit descriptions from Australian undergraduate programs. LOs were examined and categorized as 'explicit', 'implied', 'mixed', 'ambiguous' or 'nil' for both low- and high-acuity content. LOs were categorized as explicit where they directly referred to acuity-related terminology, such as non-emergency, primary care, time-critical, or acute. LOs were categorized as implied where acuity was suggested through context, and as ambiguous where reference to acuity was uncertain.

Results: Fifteen undergraduate programs were included with 1,770 LOs analyzed. Of these, 207 were determined to refer to low-acuity care with 23 categorized as explicit, 16 as implied, 68 as mixed, and 100 as ambiguous. In contrast, 485 LOs referred to high-acuity care with 234 categorized as explicit, 165 as implied, 68 as mixed, and 18 as ambiguous. When explicit and implied categories were combined, 39 of 1,770 LOs referred to low-acuity care, compared with 399 for high-acuity care.

Discussion: The findings of this study suggest considerable heterogeneity across LOs, particularly in how low-acuity care is represented compared to high-acuity. This may limit the articulation of expected graduate capabilities in assessment, management, and non-conveyance decision-making for patients requesting ambulance care for low-acuity conditions.

Conclusion: Greater representation of low-acuity care in undergraduate paramedicine program LOs may support closer alignment between graduate preparedness for practice and contemporary ambulance service demand. These findings may inform future curricula design in low-acuity care.

INTRODUCTION

Emergency medical service (EMS) attendance to low-acuity conditions has increased over the past two to three decades, contributing to a substantial volume of ambulance caseload in

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Australia and internationally (Andrew et al., 2020; Booker et al., 2015; Eastwood et al., 2016; Lowthian et al., 2011; Productivity Commission, 2025). As a result, paramedics in many EMS systems around the world are no longer defined solely by emergency response and transport to hospital (O'Cathain et al., 2018). They are increasingly being recognized as mobile healthcare professionals, who are required to manage a broad range of needs, including low-acuity and chronic presentations that may be appropriately addressed within the community setting (Booker et al., 2015; Eastwood et al., 2019; Eaton et al., 2021). Accordingly, managing low-acuity cases and avoiding unnecessary conveyance to an emergency department (ED) has become integral to contemporary paramedic practice within Australia and comparable EMS systems internationally (Blodgett et al., 2021; Eastwood et al., 2018; Ebben et al., 2019; Heinonen et al., 2022; Lederman et al., 2020; Oosterwold et al., 2018).

Currently, there is no universally accepted definition of low-acuity with the term often used alongside descriptors such as non-urgent, non-emergency, non-acute, non-serious, non-conveyance, or primary care suitable (Binks et al., 2021; Dinh et al., 2016; Thompson et al., 2011). Definitions of low-acuity cases have been described as vague and subjective, with prior work highlighting the need for clearer descriptors (Binks et al., 2021; Stephens & Broome, 2017). For the purposes of this study, low-acuity refers to patient presentations that, following paramedic assessment, are clinically stable and non-time-critical, with a low risk of deterioration, and do not require emergency paramedic intervention or conveyance to an ED. These presentations are generally suitable for management within the community, including on-scene paramedic care, self-care advice, referral to a primary care physician or another appropriate healthcare service (Andrew et al., 2020; Carter et al., 2025; Eastwood et al., 2018; Wilkinson-Stokes et al., 2024). Examples of presentations that may fall within this definition include minor injuries, musculoskeletal sprains and strains, self-limiting gastrointestinal symptoms, ear, nose and throat conditions, dental concerns, mild skin or allergic conditions, common upper respiratory tract infections, and psychosocial concerns (Ambulance Tasmania, 2017; Berry et al., 2024; Dinh et al., 2016; Eastwood et al., 2019; Halter et al., 2011; Vella et al., 2022). This definition is not intended to imply that low-acuity presentations are always risk-free or straightforward, as they can involve clinical and psychosocial complexity, diagnostic uncertainty, and have the potential for deterioration.

With over 50% of calls for ambulance assistance in Australia not categorized as an emergency, ambulance services have introduced several strategies to manage the increasing low-acuity demand (Eastwood et al., 2016; Wilkinson-Stokes et al., 2024; Wilkinson-Stokes et al., 2025). These include secondary telephone triage, non-conveyance or 'treat and refer' guidelines for paramedics, and specialist roles such as extended care paramedics (ECP), community paramedics (CP), or paramedic practitioners (Eastwood et al., 2015; Shannon et al., 2023; Snooks et al., 2004; Wilkinson-Stokes et al., 2025). Despite the success of these strategies, low-acuity presentations remain a routine part of the caseload for generalist paramedics working on emergency ambulances (Eastwood et al., 2019). However, previous research has indicated that paramedics often feel underprepared to manage some low-acuity conditions, particularly where additional patient assessment skills or higher levels of clinical reasoning are required (Carnicelli et al., 2024).

A contributing factor to this appears to be insufficient education and training provided to paramedics to support the development of additional skills and clinical reasoning

(Carnicelli et al., 2024; Johansson et al., 2022; Lederman et al., 2019; Vella et al., 2024). Where ambulance services have provided training programs to support the introduction of non-conveyance guidelines or decision-making tools, their impact on non-conveyance was generally minimal (Carnicelli et al., 2024). This was often due to the variability in the duration and content of these programs, resulting in paramedics feeling they provided limited assistance to support assessment and decision-making (Carnicelli et al., 2024). In comparison, post-graduate education provided to train paramedics as ECPs or CPs, has been positively associated with improving patient assessment skills and non-conveyance decisions (Carnicelli et al., 2024). However, while this level of education may be essential for entry into specialist roles, it is not required for all low-acuity cases and it would be impractical to expect all paramedics undertake such training (Carnicelli et al., 2024; Hobbs et al., 2021; Wankhade, 2016). Thus, there remains questions around the educational preparation necessary to support low-acuity practice for generalist paramedics, including the required level, the type of content, and where it is positioned along the educational spectrum. Considering the benefits and limitations of in-service and post-graduate training, it would seem that undergraduate education may provide an important avenue to provide the foundations of low-acuity practice, especially given they are the main entry pathway into paramedicine in Australia and comparable systems around the world (Eaton, 2023; Hickson et al., 2015).

In the Australian context, entry to practice and subsequent employment with one of the eight state or territory-based ambulance services generally requires the completion of an undergraduate (bachelor) degree. These programs are delivered by several universities nationwide and must comply with accreditation standards set by the Paramedicine Board of Australia (PBA) (Paramedicine Board of Australia, 2020). Additionally, programs must address the PBA's professional capabilities, including the ability to manage "the full range of patient presentations and circumstances" (Paramedicine Board of Australia, 2021). Although these standards establish a regulatory framework for accreditation and quality assurance, they do not prescribe a standardized curriculum (Paramedicine Board of Australia, 2021; Smith et al., 2023; Weber et al., 2025b; Weber et al., 2021). As a result, each university determines its own program structure, subject units, learning outcomes, content, assessments, and clinical placement requirements (Smith et al., 2023; Weber et al., 2025b; Weber et al., 2021). Although variation exists between individual programs, their curricula appear to be predominantly emergency care focused (O'Meara et al., 2017; Weber et al., 2025a, 2025b). In contrast, primary care content, which is closely aligned with low-acuity practice, represents just over seven percent of curricula (Weber et al., 2025a). This limited focus on non-emergency practice has been recognized by undergraduate students, who have described a disconnect between the predominance of high-acuity education compared to the volume of low-acuity cases they encounter during emergency ambulance placement (Devenish, 2014; Thompson, 2020).

Considering that a substantial proportion of paramedic caseload involves low-acuity presentations, undergraduate curricula may be increasingly required to prepare graduates for a broader range of non-emergency healthcare needs. However, this should not come at the expense of emergency content that is central to the paramedic role and its professional identity. The educational challenge, therefore, is how to retain this focus while also ensuring graduates develop the knowledge and capabilities required to appropriately assess and manage low-acuity patients; while ensuring they gain a consistent baseline

level of education across the various programs. This has been a noted concern in other content areas of undergraduate paramedicine in Australia (Parent et al., 2020; Peasey et al., 2025).

Currently, limited research has examined how preparation for low-acuity practice is articulated within Australian undergraduate paramedicine education. Subject unit learning outcomes (LOs) provide one means to explore this, as they describe the knowledge, understanding, and capabilities that learners are expected to demonstrate at the end of a period of learning; as well as guide educators in curriculum design, assessment, and program quality assurance (Adam, 2008; Adams, 2015; Hadjianastasis, 2017). Examining LOs may therefore offer insight into how low-acuity care is represented within entry-to-practice curricula. Thus, this study aimed to explore how low-acuity content is represented in subject unit LOs within Australian undergraduate paramedicine programs. For this study, representation referred to the extent to which low-acuity care was present, visible, and identifiable within LOs. Further, given the limited research examining low-acuity care within undergraduate curricula, this study was exploratory in nature.

The following questions guided the research:

1. How do unit LOs represent low-acuity knowledge, skills, and practice?
2. What is the relative volume and distribution of LOs referring to low-acuity content compared with high-acuity content across programs?
3. What terminology is used within unit LOs to describe low-acuity clinical practice?

METHODS

Research Approach

This study utilized directed qualitative content analysis to examine publicly available unit LOs from Australian undergraduate paramedicine programs (Hsieh & Shannon, 2005). Content analysis is a systematic method for analyzing the structure and meaning of text within its context and is well suited to curriculum document analysis (Bowen, 2009; Dalglish et al., 2020; Krippendorff, 2018). The analysis was guided by a pre-defined conceptual distinction between low- and high-acuity practice as informed by the literature. This shaped the development of search terms, identification of relevant LOs, and the categorization framework. While primarily deductive, the process remained iterative, with terms and category application refined through repeated reading, comparison, and moderation. This aligned with a reflexive approach to the process, allowing for the adaptation of categories as the text was analyzed (Elo & Kyngäs, 2008; Hsieh & Shannon, 2005; Morgan, 2022). Further, a pragmatic ontological and epistemological approach informed the research, with LOs treated as curriculum artifacts that provided useful, but partial insight into how programs represent expected low-acuity learning. Accordingly, the analysis of LOs aimed to produce findings that were practically relevant for future curriculum development (Schreier, 2012).

For this analysis, low-acuity was classified according to the definition provided in the introduction and how it was represented and contextualized within unit LOs and descriptions. This included references to clinically stable, non-urgent, non-emergency, primary or community-based care, non-conveyance, referral pathways, and other alternatives to ED care. High-acuity content generally referred to life-threatening, time-critical, acute or

emergency illness and injury requiring urgent paramedic intervention to prevent deterioration or death (Ibsen et al., 2021; Kayambankadzanja et al., 2022). This classification was used as an analytic distinction rather than a fixed clinical dichotomy, as acuity is a dynamic concept where clinical risk may evolve over time and presentations initially appearing as low-acuity, may require escalation of care including conveyance to an ED.

Research Setting

At the time of data collection in June 2024, 18 out of 42 Australian universities offered a total of 25 pre-registration paramedicine degree programs (Australian Health Practitioner Regulation Agency and National Boards, 2024). Eligible programs were standalone undergraduate bachelor-level degrees leading to registration as a paramedic with the PBA. Superseded, graduate entry, and combined degree programs (e.g. paramedicine and nursing) were excluded as they could influence the analysis with content that is not usually included in undergraduate curricula, such as nursing units specific to primary healthcare, child and adolescent health, or community care.

Sources of Data

For this study, the terms 'program', 'unit', and 'learning outcome' were adapted from Fennell et al. (Fennell et al., 2025). A program referred to an undergraduate degree leading to the conferral of a bachelor-level qualification in paramedicine. A unit referred to an individual component of study within a program, often referred to as a subject. LOs referred to statements outlining what students are expected to achieve at the completion of an individual unit and how understanding is to be demonstrated. Curriculum data were sourced from publicly available university websites and included (where available), course overviews, program structure (year and semester), program unit descriptions and their LOs.

Data Extraction

Eligible undergraduate degrees were identified through the PBA's publicly available online list of accredited programs and screened against the inclusion criteria. Included programs where then accessed through their respective university's homepage. Course webpages were accessed, checked and re-checked, with all publicly available curriculum information extracted into a structured Excel™ (Microsoft Corporation, USA) spreadsheet, which was piloted and refined as required. Curriculum artifacts from each university program were extracted and transferred verbatim into separate spreadsheets. Extracted data included course overview, program structure, and all program units, which were separated into their year and semester of study. Data extraction and charting was conducted by the first author and checked by the second. Only core program units were extracted to ensure comparability across programs. Elective units were excluded as they were not consistently available in all programs and are usually units of study outside the main curriculum.

After extraction, curriculum artifacts were repeatedly read and re-read to identify low- and high-acuity terms and synonyms. Terms were guided by the analytical distinction between low- and high-acuity care as previously described and by how low-acuity is represented in the literature (Allana & Pinto, 2021; Ambulance Tasmania, 2017; Booker et al., 2015; Carnicelli et al., 2024; Eastwood et al., 2019; Mills et al., 2023; Wilkinson-Stokes

et al., 2024). Search terms were iteratively refined following initial screening and re-reading, resulting in the generation of two separate word lists containing both explicit and implicit low- and high-acuity terms (Table 1 and 2). In this analysis, some terms were classified according to their contextual meaning. For example, the term 'urgent care' was treated as a community-based service-model that provides a primary care alternative to attending an ED for non-life-threatening conditions (Carter et al., 2025). In comparison, the term 'urgent' was treated as a high-acuity descriptor, as it is often used to refer to acute conditions that may deteriorate without a timely response or intervention (Ambulance Tasmania, 2017; Forero & Nugus, 2012). The first two authors independently conducted the word searches and compared findings, with any differences resolved by discussion or moderation with the third author if required. Where there was uncertainty if a unit or LOs should be included in the analysis, unit descriptions were consulted to provide additional context.

Low-Acuity Word Terms
"primary care" OR "primary healthcare" OR "primary health" OR "urgent care" OR "community paramedicine" OR "community paramedic" OR "non emergency" OR non-emergency OR non-complicated OR non-urgent OR "non urgent" OR sub-acute OR "low acuity" OR low-acuity OR "lower acuity" OR non-acute OR GP OR "general practice" OR referral OR "alternative care pathways" OR "alternative treatment pathways" OR "alternate management pathways" OR "alternative pathways" OR "inter-disciplinary care pathways" OR "health care pathways" OR "complementary management pathways" OR "extended care" OR "extended scope" OR "community healthcare" Additional terms added Extended scope, complementary pathways, collaborative pathways, collaborating agencies, interdisciplinary care pathways, discharge planning, other related health setting, community practice.
High-Acuity Word Terms
emergency OR emergencies OR emergent OR "emergency care" OR "emergency management" OR acute OR urgent OR high-acuity OR "high acuity" OR resuscitation OR "basic life support" OR "intermediate life support" OR "advanced life support" OR life-threatening OR "life threatening" OR "life threat" OR "critical care" OR "critical conditions" OR "critical situations" OR "critical illness" OR "critically ill" OR "critically injured" OR "critical injury" OR "critical injuries" OR "time critical" OR "serious injury" OR "serious illness" OR multi-trauma OR "multi trauma" OR "first aid" OR "mass casualty" OR "multi-casualty" OR "major incident" OR "major incidents" OR disaster Additional terms added Cardiac arrest, advanced care, emergent, defibrillation, external cardiac compressions, serious injury or illness, peri-arrest, deteriorating patient, altered conscious state, post-arrested patient, advanced cardiac life support, shock, time criticality.

Table 1. Low- and high-acuity search terms.

Extracted LOs were categorized as explicit, implied, mixed, ambiguous, or nil according to the presence and framing of acuity-related terms (Table 2 and 3). These categories were adapted from the work of Murray-Parahi et al., who examined primary healthcare content within undergraduate nursing curricula (Murray-Parahi et al., 2020). In the present study, the structural classification was retained, while category definitions were refined to reflect acuity distinctions within the paramedicine context. Once the categories and their definitions were agreed to and finalized, the LOs underwent several rounds of categorization and re-categorization, to strengthen the consistency and trustworthiness of the analysis (Krippendorff, 2018). Further, LOs were not categorized in isolation, with the information in each unit including LO wording, unit title, and unit description carefully examined to determine whether they referred to a low- and/or high-acuity context.

The process of categorization was conducted independently by two members of the research team (first and second authors), before meeting to compare decisions and resolve

Category	Description
LA-E	LO contains explicit (E) reference to low-acuity content defined by the presence of a low-acuity term(s); or there was direct reference to low-acuity content within the context of the LO and/or the unit description and/or the unit title.
LA-I	The reference to low-acuity content in the LO was implied (I) through context, setting, or phrasing but was not explicit in the LO and/or the unit description and/or the unit title.
Mixed	LO contains a mix of either explicit and/or implied low- and high-acuity content; Or the LO was, or appeared to be, referring to both low- and high-acuity content, within the context of the LO and/or the unit description and/or the unit title.
LA-A	Presence of low-acuity content in the LO was ambiguous (A) as the reference was either vague, weak, or uncertain, either within context of the LO and/or the unit description and/or the unit title.
Nil	LO did not mention or did not refer to low-acuity content or term(s), and/or appeared unrelated to low-acuity content within the context of the LO and/or the unit description and/or the unit title.

Table 2. Low-acuity category definitions.

Category	Description
HA-E	LO contains explicit (E) reference to high-acuity content defined by the presence of a high-acuity term(s); or there was direct reference to high-acuity content within the context of the LO and/or the unit description and/or the unit title.
HA-I	The reference to high-acuity content in the LO was implied (I) through context, setting, or phrasing but was not explicit in the LO and/or the unit description and/or the unit title.
Mixed	LO contains a mix of either explicit and/or implied high- and low-acuity content; Or the LO was, or appeared to be, referring to both high- and low-acuity content, within the context of the LO and/or the unit description and/or the unit title.
HA-A	Presence of high-acuity content in the LO was ambiguous (A) as the reference was either vague, weak, or uncertain, either within context of the LO and/or the unit description and/or the unit title.
Nil	LO did not mention or did not refer to high-acuity content or term(s), and/or appeared unrelated to high-acuity content within the context of the LO and/or the unit description and/or the unit title.

Table 3. How-acuity category definitions.

any discrepancies. Where uncertainly remained, moderation was undertaken with the third author who was independent from the process. Ensuring one researcher remained independent allowed for further investigator triangulation, strengthening the credibility, reliability, and confirmability of the categories, as they challenged interpretations, assumptions, and any potential biases of the primary coders (Lincoln & Guba, 1985; Noble & Heale, 2019; Schreier, 2012). Comments were recorded as text during categorization to justify decisions, support reflexivity, and enable coding audit.

Ethics Statement

Ethics approval was not required for this study as it did not involve human or animal research. Curriculum information was accessed from open and publicly available websites. All university data including names of institutions, program titles and units have been deidentified. The study is also part of an approved PhD program for the first author.

RESULTS

Overview of Programs and LOs

A total of 25 pre-registration paramedicine programs were screened, with 15 standalone undergraduate bachelor programs included for analysis (Figure 1). Across these programs, 1,770 LOs from 384 units were analyzed. Of these, 1,206 (68%) LOs were located in units containing references to low- or high-acuity content and were included in the categorization process. The remaining 564 (32%) LOs were not categorized as they were

located in units with no identified acuity-related content such as those specific to the human biosciences, research, professionalism, or health service management.

Across the full dataset of 1,770 LOs, explicit or implied reference to low-acuity care was limited. Thirty-nine LOs, representing 2.2% of all the LOs analyzed, were categorized as low-acuity explicit or implied. In comparison, 399 LOs representing 22.5% of all the LOs analyzed, were categorized as high-acuity explicit or implied. High-acuity care was identifiable at approximately ten times the frequency of low-acuity care. The numerical breakdown of low- and high-acuity LO categories across universities is presented in Tables 4 and 5, with the corresponding distributions graphically represented in Figures 2 and 3.

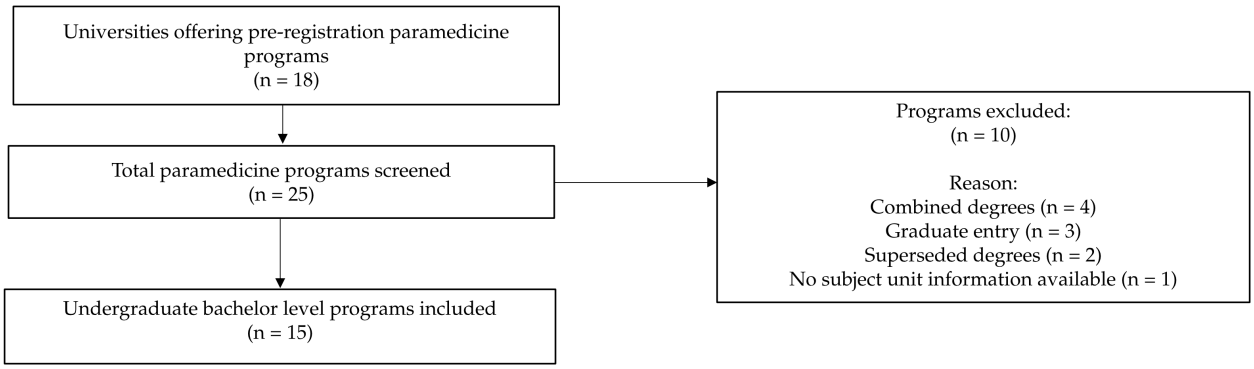


Figure 1. Program screening and inclusion.

Low-Acuity Learning Outcomes

Of the 1,770 LOs analyzed, 207 LOs were identified as referring to low-acuity content. These included 23 categorized as explicit, 16 as implied, 68 as mixed, and 100 as ambiguous. A further 199 LOs were found to have no reference to low-acuity care (Table 4). Low-acuity LOs were distributed across 88 units, representing 23% of the 384 units examined. The distribution of these units varied across the 15 programs, with six programs containing less than five units, eight programs between five and 10 units, and one program with more than 10 units (range: 2-12).

Explicit low-acuity LOs were found in 10 of the 88 identified units. Six of these units were located in the final year of their respective programs, three were located in the first year, and one in the second year. Implied low-acuity LOs were identified in 11 units, while mixed and ambiguous LOs were distributed across 45 and 46 units respectively.

Across the included programs, seven of the 15 contained units primarily or mostly dedicated to low-acuity care such as primary care, extended care, or community paramedicine. One university frequently used the term 'primary healthcare' across various elements of its program. However, no LOs within this program were categorized as low-acuity explicit.

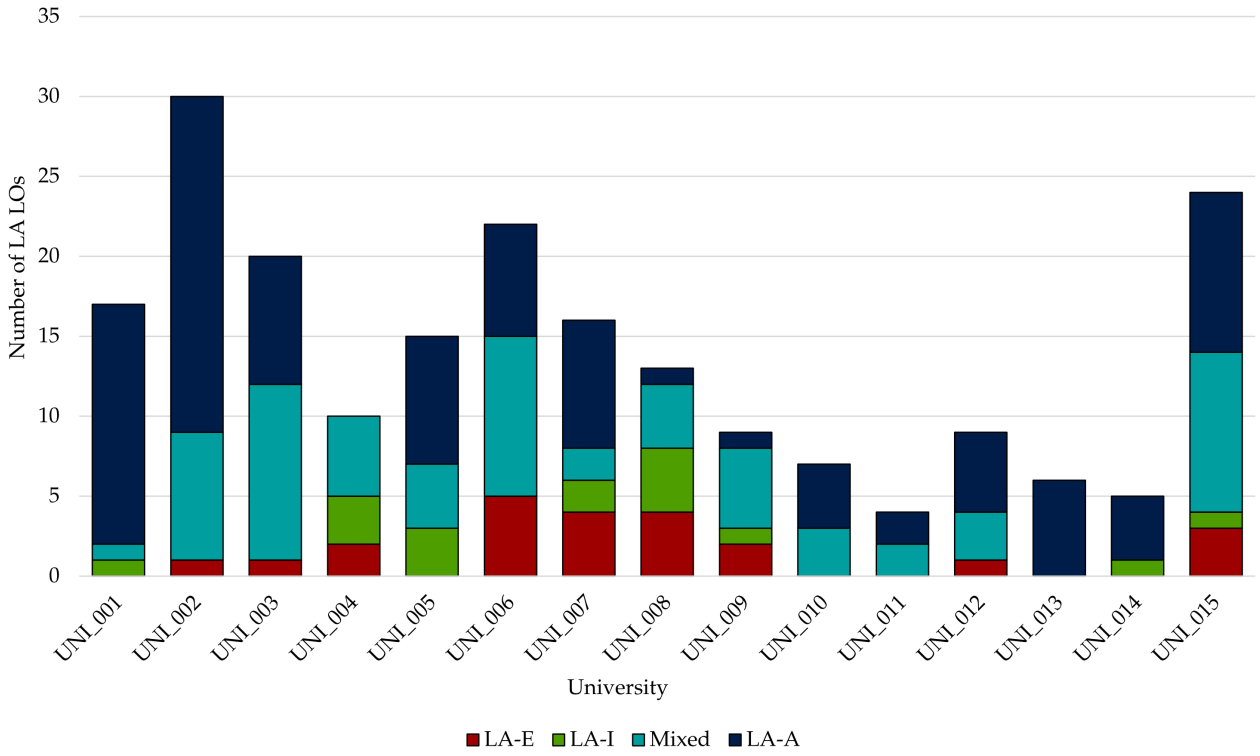


Figure 2. Number and type of LOs categorized as low-acuity by university.
Abbreviations: LA-E=low-acuity explicit LO; LA-I=low-acuity implied LO; mixed=mixed low- & high- acuity LO; LA-A = low-acuity ambiguous LO.

University	Number of LA-E LOs	Number of LA-I LOs	Number of Mixed LOs	Number of LA-A LOs	Total LA LOs
UNI_001	0	1	1	15	17
UNI_002	1	0	8	21	30
UNI_003	1	0	11	8	20
UNI_004	2	3	5	0	10
UNI_005	0	3	4	8	15
UNI_006	5	0	10	7	22
UNI_007	4	2	2	8	16
UNI_008	4	4	4	1	13
UNI_009	2	1	5	1	9
UNI_010	0	0	3	4	7
UNI_011	0	0	2	2	4
UNI_012	1	0	3	5	9
UNI_013	0	0	0	6	6
UNI_014	0	1	0	4	5
UNI_015	3	1	10	10	24
Total	23	16	68	100	207

Table 4. Low-acuity category definitions.
Abbreviations: LA-E=low-acuity explicit LO; LA-I=low-acuity implied LO; mixed=mixed low- & high- acuity LO; LA-A = low-acuity ambiguous LO.

High-Acuity Learning Outcomes

Of the same 1,770 LOs analyzed, 485 were identified as referring to high-acuity content. These included 234 LOs categorized as explicit, 165 as implied, 68 as mixed, and 18 as ambiguous (Table 5). A further 315 LOs were categorized as having no reference to high-acuity care. High-acuity LOs were distributed across a total of 160 units, representing 41.7% of all 384 units analyzed. The distribution of these units varied across the 15 programs, with four programs containing less than 5 units, nine programs between five and 10 units, and two programs with more than 10 units (range: 1-14).

Explicit high-acuity LOs were found in 97 of the 160 identified units. Twenty-one of these were located in the first year of their respective programs, 43 in the second year, and 33 in the final year. Implied high-acuity LOs were identified in 80 units, while mixed and ambiguous LOs were distributed across 45 and 15 units respectively.

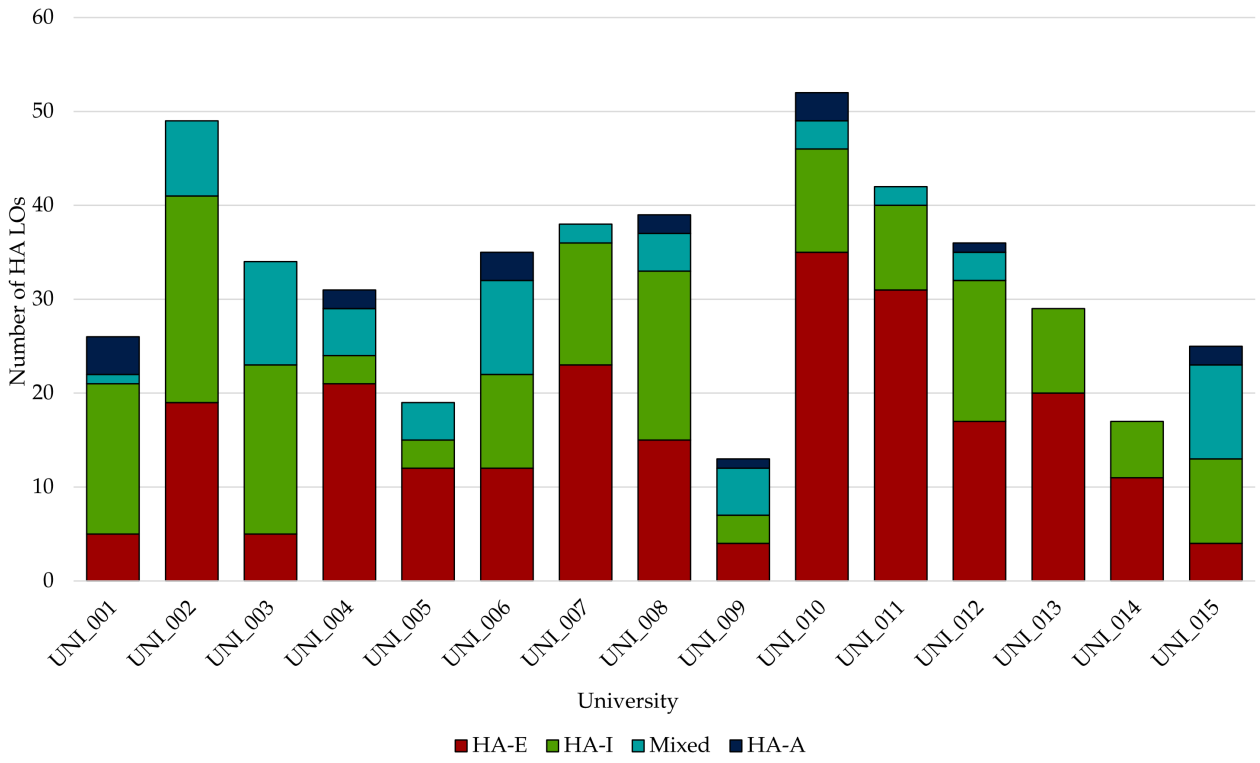


Figure 3. Number and type of LOs categorized as high-acuity by university.
Abbreviations: HA-E=high-acuity explicit LO; HA-I=high-acuity implied LO; mixed = mixed high- & low- acuity LO; HA-A=high-acuity ambiguous LO.

DISCUSSION

This study explored how low-acuity care was represented within publicly available LOs from Australian undergraduate paramedicine programs. The findings suggest considerable variation in the volume, distribution, clarity, and terminology used to refer to low-acuity in unit LOs. As our study was limited to analyzing the specific content of LOs and unit descriptions, which only represent one component of curriculum design, it does not allow for conclusions to be drawn regarding the actual low-acuity content that may be delivered through teaching and assessment practices within these programs.

University	Number of HA-E LOs	Number of HA-I LOs	Number of Mixed LOs	Number of HA-A LOs	Total HA LOs
UNI_001	5	16	1	4	26
UNI_002	19	22	8	0	49
UNI_003	5	18	11	0	34
UNI_004	21	3	5	2	31
UNI_005	12	3	4	0	19
UNI_006	12	10	10	3	35
UNI_007	23	13	2	0	38
UNI_008	15	18	4	2	39
UNI_009	4	3	5	1	13
UNI_010	35	11	3	3	52
UNI_011	31	9	2	0	42
UNI_012	17	15	3	1	36
UNI_013	20	9	0	0	29
UNI_014	11	6	0	0	17
UNI_015	4	9	10	2	25
Total	234	165	68	18	485

Table 5. Number of LOs coded as high-acuity by university.
Abbreviations: HA-E=high-acuity explicit LO; HA-I=high-acuity implied LO; mixed = mixed high- & low- acuity LO; HA-A=high-acuity ambiguous LO.

Volume of Low- and High-Acuity Learning Outcomes

This analysis revealed that LOs representing high-acuity concepts were considerably more common, with 399 categorized as high-acuity explicit or implied compared to 39 for low-acuity. This tenfold difference suggests that undergraduate curricula continue to frame paramedicine mostly through a high-acuity lens, which is consistent with previous research into Australian programs (Weber et al., 2025a). The focus on high-acuity teaching is not unexpected, as strong educational preparation to manage life-threatening and emergency conditions is central to the role of a paramedic. However, where the representation of low-acuity practice is variable or limited, it may be challenging to demonstrate that graduates from different programs are equally prepared to assess low-acuity presentations and determine whether non-conveyance is safe and appropriate (Halter et al., 2011; Sheffield et al., 2016; Thompson, 2013; Vella et al., 2024). Previous research has identified variability in curriculum content across Australian undergraduate programs, suggesting that graduates may enter professional practice with differing levels of preparation (Parent et al., 2020; Peasey et al., 2025; Weber et al., 2025b) Therefore, clearer articulation of low-acuity care within LOs may support improved curriculum alignment with patient assessment, risk stratification, safety-netting, and decision-making skills required of contemporary paramedics.

University programs in Australia have responded to the changing landscape of paramedicine by including low-acuity content. This is evidenced within the extracted curricula artifacts with several programs offering specific units in extended care or community paramedicine, as well as clinical placement time in primary care settings (Eaton, 2023; Weber et al., 2025a, 2025b). However, it has been remarked that despite these inclusions, there has been little change since the beginning of professional registration in 2018, with the integration of this content remaining largely insufficient (Weber et al., 2025b). Based on previous research and our analysis of LOs, low-acuity practice appears to be under-represented within Australian undergraduate programs, despite the recog-

nition that a substantial and increasing proportion of emergency ambulance caseload is low-acuity in nature.

Distribution and Representation of Low-Acuity Practice within Learning Outcomes

Low-acuity content appeared to be distributed across programs in two main ways: through dedicated units, often titled as extended care or community paramedicine, or within broader units alongside high-acuity topics. In other units, even where the unit description indicated a focus on low-acuity care, there was mixing with high-acuity topics. For example, in one program, a low-acuity unit also included emergency birth and birth complications, as well as newborn resuscitation. In other programs, community paramedicine and low-acuity care were integrated with topics such as advanced life support, toxicology, general acute conditions, trauma, traumatic cardiac arrest, and shock. The combination of this content may reflect that patient presentations can shift along an acuity spectrum and that conditions initially appearing or assessed as low-acuity, have the potential to deteriorate or require escalation in care. This may help students develop an appreciation of the potentially complex nature of some low-acuity presentations, which is especially important for certain patient populations and conditions that may have poorer outcomes if this is under-recognized. However, where content is combined without articulation within LOs, intended low-acuity learning may be overshadowed by the larger volume of high-acuity content. It is also possible that the mixing of content may represent a means of consolidating topics to accommodate new areas of practice as they emerge. A potential consequence of this is overcrowding the curricula, especially where there may be competing demands to include new content, which is a recognized challenge within other university programs (Begley et al., 2025; Dalley et al., 2008; Dissanayake et al., 2024; Slavin & D'Eon, 2021).

The variation observed across programs also raises questions about whether broader curriculum guidance could support more consistent representation of low-acuity learning and ensure a common baseline of educational preparation (Parent et al., 2020; Weber et al., 2025b). Australian paramedicine programs must align with accreditation standards and professional capability frameworks; however, these do not prescribe recommended curriculum content. Previous research has suggested that a national curriculum may be one potential solution to address the known variability across programs (Parent et al., 2020; Peasey et al., 2025; Weber et al., 2025b). This could include a set of exemplar LOs to support the scaffolding of all areas of practice across the individual programs, including low-acuity care, while preserving institutional autonomy and local program design (Peasey et al., 2025).

Clarity of Learning Outcomes

A key challenge encountered and reflected on in this analysis was interpreting the intended meaning of the LOs. A large proportion of low-acuity LOs were categorized as ambiguous (n=100), often because their reference to low-acuity remained uncertain, even after repeated review and moderation. This ambiguity commonly reflected broad and generic clinical wording, including references to holistic approaches, patient care activities, advanced medical presentations, and complex medical etiologies. Similar ambiguity occurred where units titled as emergency care focused also included chronic disease management. The term ‘chronic’ appeared, in some instances, to be used as a

possible surrogate for low-acuity without being clearly articulated. In contrast, explicit low-acuity categorization was supported by direct references to primary care, non-acute or non-emergency presentations, discharge planning, and referral to community or alternative healthcare services. Additionally, implied low-acuity categorization was suggested through context and included references to person-centered care, biopsychosocial models, and lifespan healthcare. The use of broad or inconsistently applied curriculum language is not unique to low-acuity care, with similar issues reported in relation to other content areas within Australian paramedicine curricula, including pediatrics and mental health (Parent et al., 2020; Peasey et al., 2025).

The high proportion of ambiguous LOs should also be interpreted in light of the differences in institutional reporting practices. Australian universities independently determine the structure, wording, and level of detail they provide in their publicly available program information. Consequently, some programs may present LOs in more detailed clinical terms, whereas others may use broader statements in which low-acuity care is embedded rather than explicitly stated. This variability may have affected the categorization of LOs and limited direct comparisons between programs. Thus, ambiguous language in LOs may reflect limitations in public curriculum documentation rather than an absence of certainty in their low-acuity content. However, from a representation perspective, this ambiguity is important, as content not clearly visible within LOs may be less identifiable to current and prospective students, which may potentially diminish its perceived relevance to professional preparation.

Ambiguously framed LOs can also make it challenging for students and educators to determine their purpose, expected depth of learning, capabilities to be acquired, and how they link to assessment (Brooks et al., 2014; Guilbert, 2002; Hadjianastasis, 2017; Kennedy, 2006; Schoepp, 2019). It has been remarked that poorly constructed LOs can lead to their misinterpretation, which risks rendering them irrelevant and of no real practical use (Sin, 2014; Sweetman, 2019). While ambiguity can have pedagogical value, particularly when preparing students for increasing clinical complexity and uncertainty, it should be purposeful rather than the result of unclear framing (Kennedy, 2006; Purvis & Winwood, 2023). For low-acuity care, clearer articulation may provide a greater appreciation for the fact that certain presentations can be challenging, requiring thorough patient assessment and sound clinical decision-making, rather than potentially being viewed as a distraction from "real" high-acuity work (Simpson et al., 2017). It should be noted that this detail may be present in the actual delivered content of the programs including lectures and tutorials. However, this was not the focus of the present study and may be an area for future research. The prevalence of ambiguous low-acuity LOs also highlights the potential difficulty of articulating curriculum intent in this area. However, it is generally recommended that LOs should be a direct reflection of the knowledge and capabilities that students are expected to develop in preparation for clinical practice.

Learning Outcome Terminology

Terminology used to describe low-acuity care varied across and within programs. Terms included 'low-acuity', 'lower acuity', 'non-emergency', 'non-acute', 'non-urgent', 'sub-acute', 'primary care', 'non-complex', and 'non-complicated'. While these terms may appear similar, they are not necessarily interchangeable, which was noted to occur in some programs. In particular, terms such as 'non-complex' or 'non-complicated' risk

conflating urgency with complexity, which could reinforce previously reported negative perceptions of low-acuity presentations (Simpson et al., 2017). Referral terminology also varied, with programs using phrases such as 'other appropriate health services', 'alternative management pathways', 'alternative or complementary management pathways', 'referral pathways', 'collaborative pathways' and 'interdisciplinary care pathways'. Lastly, similar variation was noted in the terminology used for specialist areas of practice including, 'community paramedicine', 'extended community paramedicine' and 'extended paramedic care'. Greater uniformity of terminology may reduce inconsistency in how low-acuity practice is represented across curricula and within the profession.

LIMITATIONS

One of the main limitations of our study is that it only explored curriculum content from publicly available online sources. As a result, our findings reflect the representation and framing of low-acuity care within the published materials, which do not provide the full view of the actual delivered content, including teaching methods, assessment tasks, or practical learning experiences. It should also be acknowledged that the information provided varied between universities, with some publishing more unit detail compared to others, which may influence the context in which some LOs were categorized. The researchers did not seek or have access to the full curriculum content of each program, which may have provided further context and clarity to our findings, especially for LOs that were categorized as ambiguous. However, such curriculum information is usually unavailable as it is the intellectual property of the respective universities and rarely made public (Murray-Parahi et al., 2020). Additionally, publicly available information may also be less detailed compared to the content provided on internal learning management systems that is available to enrolled students. This represents an area for further research, including surveys and/or interviews with paramedicine educators and students to provide clarity and context around the integration and teaching of low-acuity content.

Ambiguous LOs also posed a challenge for their interpretation and subsequent categorization, as wording did not always clearly indicate how the representation of low-acuity content was intended. Unit descriptions were used to provide additional context where uncertainty was encountered, but these only provide a brief synopsis of the unit content. While this study did not examine the full content of each program, LOs provide valuable insight into the intended areas of focus, as they directly reflect the knowledge and skills that unit and program structures are built on. In turn, these are then utilized by students to guide their interpretation of course learning priorities and ultimately how they are assessed.

A further limitation is that the curriculum artifacts examined in this study were sourced at a single point in time and program coordinators were not contacted to verify the currency of the LOs published on their webpages. As a result, during this study, universities may have made internal changes and revisions to their curricula, including LOs and content that was not publicly available at the time. It is not uncommon for programs to update their course information prior to the beginning of each new academic year, as well as engage in periodic comprehensive course review (Tertiary Education Quality and Standards Agency, 2024).

CONCLUSION

This analysis of publicly available LOs across Australian undergraduate paramedicine programs revealed considerable heterogeneity in how expected learning for low-acuity care is represented. While some programs have incorporated clearly defined low-acuity units and LOs, others represented low-acuity concepts briefly or through broad and ambiguous phrasing. These findings highlight an opportunity to review future curriculum development, including recommendations for greater representation of low-acuity care within programs, clearer articulation of baseline low-acuity capabilities that are aligned across programs, and consistent terminology for low-acuity care and community practice. The observed variation across programs also raises questions about whether broader educational policy and national guidance regarding curricula development and content may be beneficial.

Further research could also examine how low-acuity care is developed, delivered, assessed and experienced both within undergraduate programs and through professional practice. In particular, qualitative research exploring how university education, workplace learning, and clinical experience have shaped paramedic preparedness for low-acuity practice could provide useful insight for the development of capabilities required for current and future practice. This may extend the findings of the present study beyond the visible curriculum represented in publicly available information. Finally, while this study explored Australian undergraduate programs, the findings may be relevant to comparable EMS systems around the world that are also experiencing increased low-acuity demand, and where paramedics or ambulance clinicians in those systems are required to possess similar entry-to-practice education.

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RESEARCH REPORTS

PATIENT EXPERIENCES OF POSTERIOR CIRCULATION STROKE AT SYMPTOM ONSET: A QUALITATIVE STUDY

Shane Devlin, MSc, PgDip-AP*[1,2]; Mary Gilbert, BSc, PgDip[3]; Aine O'Reilly, BSc, PgCert, MSc[4]; Joanne Carolan, BSc, PgDip[4]; Thomas Walsh, MB FRCPI[3]; Tom Lee, MB, BCH, FRCPI[4]; Charles Brand, BA, MSc, PhD[1]

Author Affiliations: 1. National Ambulance Service, Ireland; 2. University College Cork, Cork, Ireland; 3. University Hospital Galway, Galway, Ireland; 4. Mayo University Hospital, Castlebar, Ireland.

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**Corresponding Author:* shane.devlin@hse.ie

ABSTRACT

Introduction: Posterior Circulation Stroke (PCS) accounts for around 20% of ischemic strokes but is missed more frequently than Anterior Circulation Stroke (ACS), mainly due to its subtle symptoms and non-specific presentation. Currently there are no studies evaluating PCS patients' experiences of their symptoms at stroke onset, and so this study aimed to evaluate this to aid in paramedic understanding and detection of PCS.

Methods: A qualitative descriptive approach was adopted. Clinical Nurse Specialists and Advanced Nurse Practitioners in Stroke purposefully sampled PCS patients confirmed by MRI and admitted to the stroke wards of University Hospital Galway and Mayo University Hospital in the West of Ireland. Once consented, semi-structured interviews were carried out, transcribed verbatim, and thematic analysis completed. Inclusion criteria were any stroke in the posterior portion of the brain confirmed by MRI, patient 18 and less than four weeks since stroke onset.

Results: Ten patients were interviewed. 90% did not believe they were having a stroke. Only 50% sought help immediately. 70% were taken to hospital by ambulance and 30% were taken by car. 20 different symptoms were reported by participants. Loss of balance was the most prevalent symptom, followed by being unable to walk unaided, dizziness, vision disturbance and headache. 60% had prodromal symptoms prior to the onset of their stroke. Qualitative analysis created three main themes: 1) Physical Disturbance, 2) Visual and Spatial Disturbance and 3) Dismissal.

Conclusion: PCS is a difficult condition for patients to recognize, which affects their help seeking behavior, delays treatment and negatively affects outcomes. These patients described a wide variety of symptoms and their reasons for dismissing them. These results may help inform future paramedic educational programs for PCS awareness and recognition in the prehospital environment.

INTRODUCTION

Stroke is the third leading cause of death in Ireland and Western Europe and is the number one cause of acquired disability (McCormack et al., 2024). It can be caused by a blockage of blood flow to the brain due to a clot (ischemic) or a bleed (hemorrhagic) (Campbell & Khatri, 2020).

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Depending on the location of the blockage, strokes can be separated into anterior circulation stroke (ACS) or posterior circulation stroke (PCS). ACS is much more common, and can have dramatic symptoms such as facial droop, arm and leg weakness and slurred speech (Tao et al., 2012). These symptoms are commonly picked up by the FAST test (face, arm, speech, time) (Harbison et al., 2003), which is the main prehospital stroke screening tool in Ireland and the UK (Feeney et al., 2016; Prehospital Emergency Care Council, 2023; C. Price & Paramedic, 2017). The posterior part of the brain consists of the cerebellum, brainstem and occipital lobes, which are responsible for functions including vision, co-ordination, balance and fine motor control. A lack of blood flow to these portions of the brain will cause a deficit in one or more of these functions (Carr, 2015). These patients therefore may not exhibit the typical 'FAST' symptoms which are the hallmark of public awareness campaigns (Irish Heart Foundation, 2020; Public Health England, 2021). The New England Medical Center Posterior Circulation Registry indicates that the most common symptoms of PCS are dizziness, unilateral arm weakness, dysarthria, headache and nausea or vomiting (Searls et al., 2012). PCS has been shown to account for around 20% of ischemic strokes (Floßmann & Rothwell, 2003; Merwick & Werring, 2014) and is missed three times more than ACS in the emergency department (ED) (Tarnutzer et al., 2017). The signs and symptoms of PCS have been shown to account for as much as 50% of missed strokes by the emergency medical services (EMS) in a recent systematic review (Jones et al., 2021).

Internationally, there is a paucity of research focused on recognition of PCS symptoms in the prehospital environment, but it is recognized to be poor (Hunt et al., 2024). A narrative review from Germany highlighted the pitfalls of PCS diagnosis, including a lack of public awareness of the symptoms and a predominated focus on large vessel occlusion/anterior stroke from EMS (Hoyer & Szabo, 2021). Recent Irish research has shown that 67% of paramedics missed the symptoms of PCS in a vignette setting and were uncomfortable of the diagnosis (Devlin & Bury, 2023). Because of this, recognition and therefore treatment is delayed, which has been shown to result in worse outcomes than their anterior circulation stroke counterparts (Sommer et al., 2018).

To date, only one study from Sweden has investigated patient reported symptoms of stroke, which showed that many patients experienced subtle and puzzling symptoms not commonly included in public awareness campaigns (Andersson et al., 2024) or typical paramedic undergraduate training (Prehospital Emergency Care Council, 2014, 2023). Most of the patients in this study, along with their families had no idea that they may be having a stroke (Andersson et al., 2024). As the FAST test is still the primary tool used in Ireland and the UK for recognition of stroke by paramedics prehospital (Feeney et al., 2016; Prehospital Emergency Care Council, 2023; C. Price & Paramedic, 2017) there may be a significant proportion of patients with subtle, less typical symptoms missed.

At the time of writing, there are no studies detailing patient reported symptoms of stroke subtypes, including PCS. Therefore, the aim of this study was to gather the patient's description of their PCS symptoms in their own words, which will allow paramedics and other healthcare professionals to gain an appreciation and understanding of the patient's experience, in order to increase recognition in the future.

METHODS

Study Design

This study took place in Galway and Mayo University Hospitals, part of the Saolta Group in the west of Ireland over a four-month period (May – August 2025). A qualitative descriptive design was used, with thematic analysis informed by Braun and Clarke (2006). The Standards for Reporting Qualitative Research (SRQR) were used to describe the research.

Semi-structured interviews (see appendix) were used to explore patients experiences of their posterior circulation stroke, with the template adapted from another qualitative study on stroke patients' experiences at symptom onset (Andersson et al., 2024), where the authors looked at general strokes rather than a PCS subset. Advanced Nurse Practitioners and Clinical Nurse Specialists in Stroke in both hospitals were approached for patient selection and data collection.

Reflexivity

The primary investigator (PI) conducted all semi-structured interviews. The researcher works as an Advanced Paramedic with the National Ambulance Service in Ireland, regularly treating acutely ill or injured patients in the community. This clinical background provided familiarity with stroke patients and their assessment and helped form the interview template. The researcher recognized that this background may have influenced data collection and interpretation, emphasizing more subtle symptoms of PCS. To address this, patients were encouraged to tell their story in their own chronological order, before exploration of specific clinical elements of their experience. The researcher was not involved in their care and kept reflective memos throughout the process to challenge assumptions and influences on data collection and analysis.

Ethics

Ethical approval was sought from the Clinical Research Ethics Committee, Saolta Group, and granted on the 28th of March 2025 (reference C.A. 3390).

Patient Selection

Purposeful sampling was employed, where PCS patients (confirmed as such by MRI) were approached by Advanced Nurse Practitioners (ANPs) and Clinical Nurse Specialists (CNS's) in Stroke and informed of the study. If consented, clinical data including age, gender, co-morbidities/past medical history, stroke type (territory) and treatment (Table 2) were collected by ANP's and CNS's. The patients were then contacted by the primary investigator (PI) to confirm inclusion in the study and arrange an interview date and time.

Inclusion/exclusion criteria are shown in Table 1.

Inclusion Criteria	Exclusion Criteria
• Posterior Circulation Stroke (ischemic and hemorrhagic) • Aged 18 and over • <4 weeks since stroke	• Stroke in any other territory • <18 • 4 weeks since stroke • Unable to participate

Table 1. Study inclusion and exclusion criteria.

Data Collection and Analysis

ANPs and CNSs collected demographic and clinical data (Table 2). Semi-structured interviews were conducted over a four-month period (May – August

2025) both in person (70%) and over the phone (30%). The median interview time was 29 minutes. These interviews were recorded with consent and transcribed verbatim. Qualitative analysis was informed by Braun and Clarke's method (Braun & Clarke, 2006). This method was chosen as it is well suited to exploratory qualitative research seeking to identify patterns of meaning across participant's accounts.

This approach allows analysis to be performed inductively, while also enabling the researcher to consider the relevance of these experiences to prehospital care. While a semi-structured interview guide was used to support consistency throughout the interviews, no a priori schema was used. The guide informed data collection while keeping the analysis inductive. Themes were generated by getting to know the data, finding patterns and generating codes, which were grouped to form sub themes and overall themes from the dataset. The target number of patients was set at ten due to staffing and timing constraints and as such, thematic saturation was not sought.

In keeping with Creswell's recommendations for qualitative validation (Creswell & Miller, 2000), rich, thick description was prioritized by presenting detailed accounts and descriptions of symptom onset and interpretation. Clarification of researcher bias through reflexivity and regular engagement with the wider research team ensured further validity of results.

Patient	Gender	Stroke Territory	Treatment
1	Male	Left cerebellar infarct and left PICA* occlusion	Transferred. Right frontal EVD* and posterior fossa craniotomy
2	Male	Left occipital infarct	DAPT*
3	Male	Right occipital infarct	Aspirin
4	Female	Left thalamic infarct	Aspirin
5	Male	Left occipital/temporal infarct	Aspirin
6	Male	Right pontine infarct	Thrombolysis
7	Male	Acute left paramedian midbrain infarct	Medical management
8	Female	Right and midbrain infarct	Transferred. EVT*
9	Male	Large PICA* territory acute left cerebellar infarct	Medical management
10	Male	Basilar artery thrombus and right cerebellar infarct	Thrombolysis

Table 2. Stroke territory and treatment.
Abbreviations: PICA = posterior inferior cerebellar artery, EVD = external ventricular drain, DAPT = dual anti-platelet therapy, EVT = endovascular thrombectomy

RESULTS

54 PCS patients presented to Galway and Mayo University Hospitals in the four-month study period. Recruitment stopped at ten patients, which represented 18.5% of the PCS population during this time period.

The median age was 70 years old, ranging from 43-80. Participants' medical history can be seen in Figure 1. Hypertension was the most prevalent co-morbidity (70%), followed by type 2 diabetes, and dyslipidemia (30%). 20% of participants had ischemic heart disease, coronary artery bypass graft (CABG), atrial fibrillation, previous stroke, aortic valve replacement and deafness. One case of atrial fibrillation was presumed to be a new onset and cited as the causative factor.

90% (9/10) did not believe they were having a stroke at the time. Only 50% (5/10) sought help immediately. 70% were taken to hospital by ambulance (with only two going immediately) and 30% were taken by car (with all these going immediately). The remainder of the ambulance group help seeking time varied from four hours to four days (Figure 2).

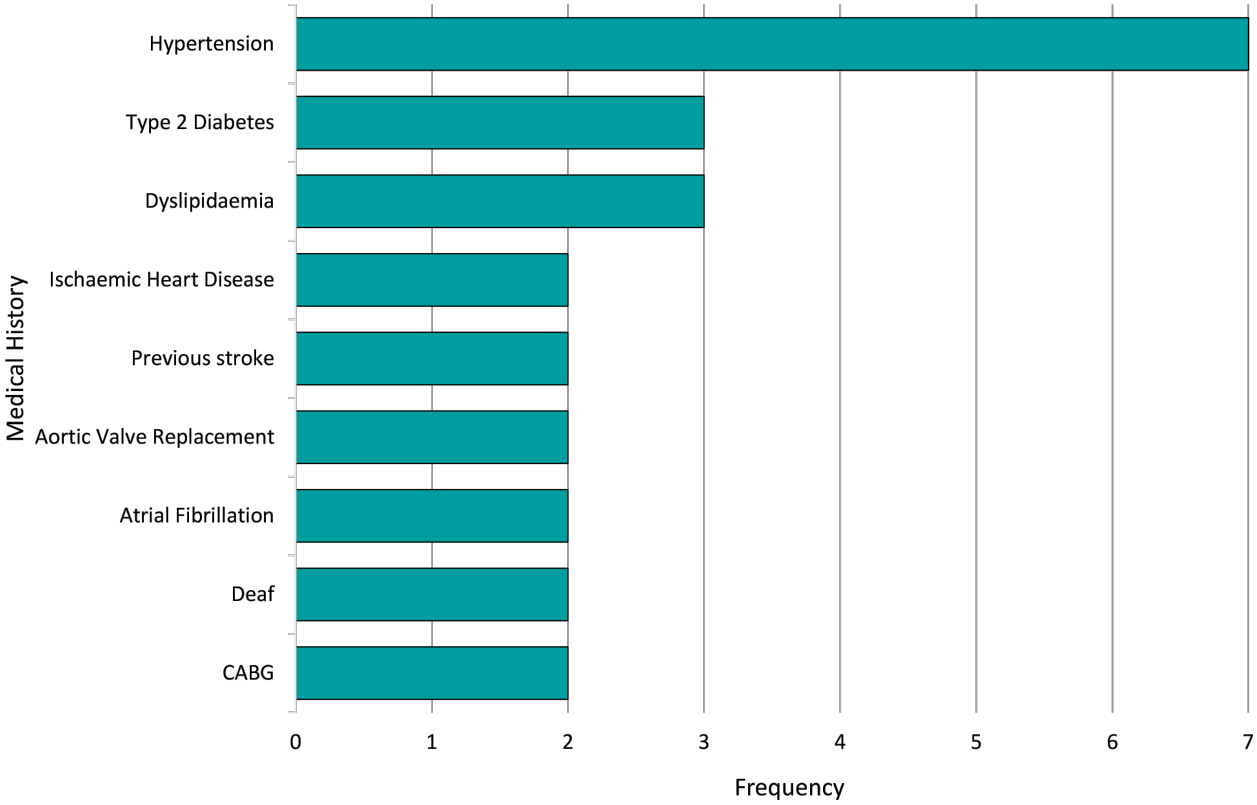


Figure 1. PCS patient's medical history.

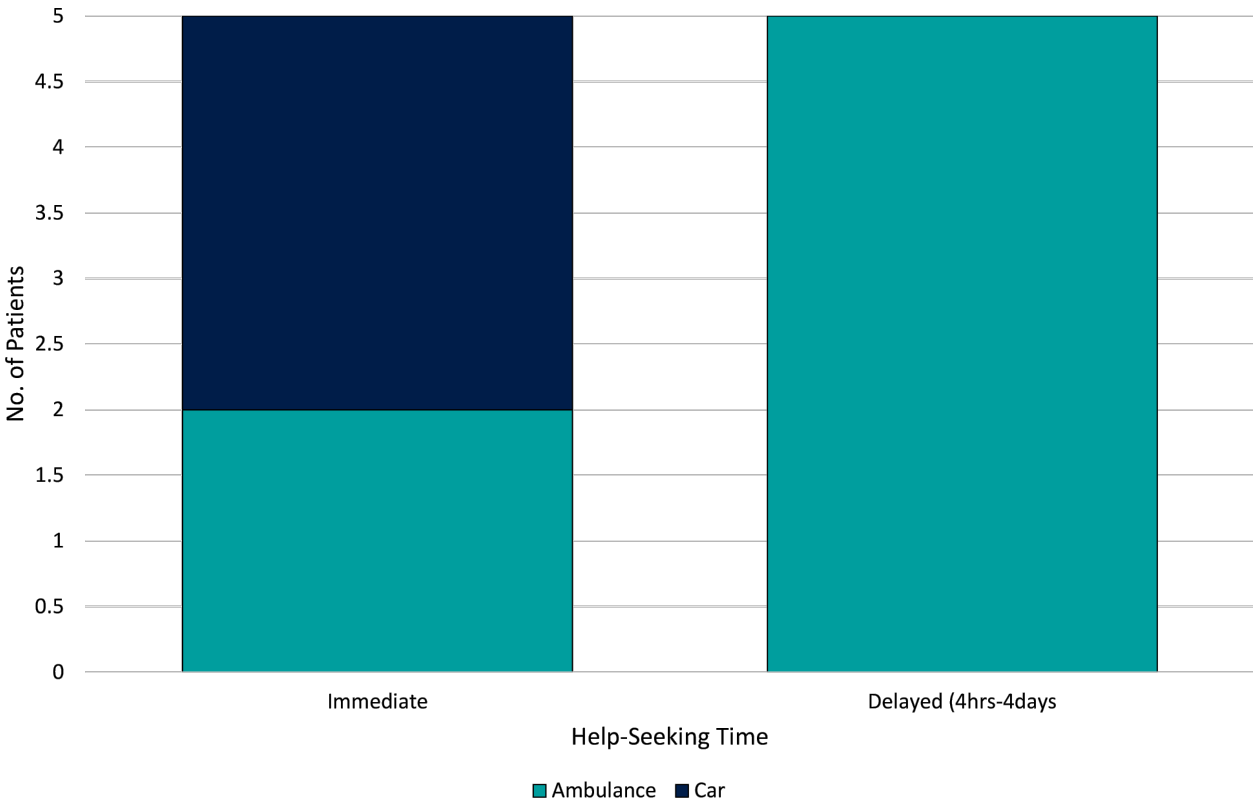


Figure 2. Help-seeking time and transport mode.

20 different symptoms were reported by the participants in this study. The median number of symptoms was five (ranging between three and ten). Loss of balance was the most prevalent noted (80%), followed by unable to walk unaided (70%), dizziness (50%), and vision disturbance and headache (both 40% occurrence). 30% (3/10) reported symptoms present in the FAST test, with two patients having speech problems and one describing arm weakness (Figure 3).

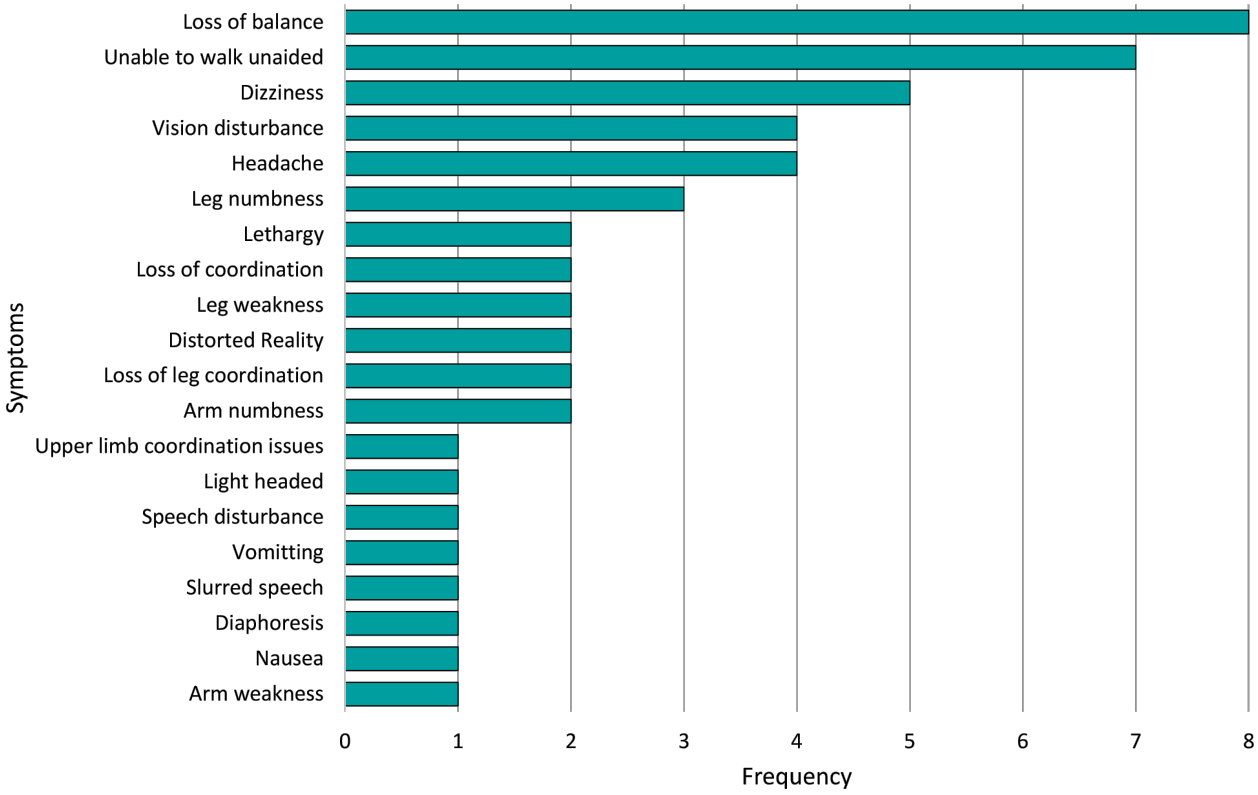


Figure 3. Patient reported symptoms of PCS.

60% (6/10) had intermittent prodromal symptoms (i.e. early signs/symptoms that appear before a more apparent illness) prior to the onset of their stroke. The most common were vision changes (40%), headache (30%), and loss of balance/coordination (30%). None of the sample group were permitted to drive in the study timeframe (within four weeks of their stroke) with two patients restricted from driving until further notice due to visual problems.

Reasons for non-recruitment of patients apart from declining included cognitive issues, memory issues, new cancer diagnosis, and being too unwell to participate.

Qualitative Analysis

Three main themes of physical disturbance, visual and spatial disturbance, and dismissal were created with separate subthemes as shown in Table 3. Due to small numbers, thematic saturation was not sought.

Patients were anonymized prior to data analysis. Participant 1 is labeled P1, participant 2 as P2 etc.

Physical Disturbance

The loss of balance or an inability to walk was a common theme among participants, but this was on a spectrum. Some could not walk at all, and others could manage walking with some assistance.

> *"I got down onto the ground. My phone was over in the kitchen, which would be about 20 feet away, and I crawled over to get my phone to call my wife who was upstairs" – P5.*

Theme	Sub-theme
Physical Disturbance	• Balance/coordination impairment, • Limb sensory disturbance • Speech impairment
Visual and Spatial Disturbance	• Visual disturbance • Vertigo • Altered reality
Dismissal	• Misattribution to benign causes • Prodromal features

Table 3. Qualitative themes.

Many described a similar pattern where they needed to hold on to something in order to walk:

> *"I was hanging onto the wall" – P8.*

> *"I had to go from chair to chair [to get to the phone]" – P3.*

Coordination varied, with some only affecting either the upper or lower limbs:

> *"I could change my top part, but I couldn't change my trousers at all" – P6.*

> *"My hands were fine….but I found it difficult to get the second trouser leg in and shoes on" – P9.*

Patients described a variety of limb symptoms, but not necessarily an arm or leg 'weakness':

> *"… my left arm, which, you know like on occasions when you're sitting in a chair and your arm would fall asleep, it kind of went fairly dead and heavy, but by the time I got to (town), it had kind of had a relaxed again with the bit of maneuvering I was doing" – P3.*

> *"(my arm) just felt like something really, really tight...like as if somebody had kind of put bandages kind of way too tight or you know if someone is taking your blood pressure and they put the thing on too tight and it's getting tighter and tighter, you know what I mean? It's just that feeling of just constriction" – P4.*

Despite being diagnosed with PCS, some patients had anterior stroke symptoms such as aphasia:

> *"When I spoke to her (my wife), my speech was slurred, even though I knew exactly what I was trying to say. And I was able to say it but. It sounded like I was drunk. Yeah, it was very slurred and very hard to get out" – P10.*

Of note, two of the participants described a difficulty in carrying out normal tasks, requiring increased concentration, that weren't noticed by others:

> *"They asked me my name and date of birth, and even though I answered those two questions, the words were there but I couldn't get them out. The words sounded okay but they weren't the words I wanted to use" – P2.*

> *"They (the paramedics) made me touch my nose and touched with my right hand and all that was fine. I did it with my left and they said, "Oh that's fine", I said no. I really had to concentrate to do that to get it right. I almost missed and I had to readjust to hit his finger" – P10.*

Some patients described varying levels of headache, from an instant 'pop' to a more nagging type of discomfort:

> *"I felt something pop in my head and I couldn't remember where I was. I didn't know where the kids were.…..and then I started vomiting" – P1.*

> *".. it wasn't really a pounding headache...you know, it was really just annoying, nagging, maybe" – P9.*

Visual and Spatial Disturbance

Many participants described experiences of visual disturbances and spatial disorientation that gave them an altered sense of reality. Vision problems were vividly described by patients:

> *"I was laying in my bed, and I opened my eyes and everything had shifted in the room. Like, so this wall here with the window was on the ceiling. The ceiling was on the (side) wall with the light sticking out of it, the bathroom door was on the floor. The floor was on this wall. It's like somebody got the room and just shifted it around…I remember going the bathroom and having to crawl there…I was like, everything's the wrong way round, everything's shifted" – P1.*

> *"I was just getting the dinner ready and when I went over to put on the oven and I couldn't distinguish which side the oven controls were on…I didn't know which control was which. I was looking at the dials, and it just wouldn't click in" – P2.*

Participants described a feeling of dizziness or vertigo-like symptoms like the room was spinning:

> *"The room was spinning like I was on a rollercoaster… Then I just puked on the floor like, like, I can't make it to the toilet" – P1.*

> *"I got really dizzy and I felt I was gonna fall. My head was going round, spinning" – P8.*

Dismissal of Symptoms

Due to the subtle nature of symptoms and a lack of knowledge on what they could be, the majority of patients dismissed their symptoms as something more benign:

> *"I didn't think this was a stroke as my hand was okay, my last stroke my hand was weak" – P6.*

Due to patient's misattributing the stroke symptoms as something else, this delayed their help seeking behavior:

> *"My niece and my sister were kind of saying you should call the doctor. And I said, oh, c'mon, I don't want the drama. And well, he [the doctor] took my blood pressure and just the symptoms and he kind of said 'when did this start?' and why didn't you come to me sooner? And I said, well, I didn't really know what it was" – P4.*

Dismissal not only occurred by the patients, but also medical staff:

> *"My speech and doing that finger to nose finger to those different situations [were] all perfect, and they came to the conclusion that it's just classical vertigo, seeing as I was able to do everything they asked me. They done a repeat scan then which showed a clot in the cerebellum" – P9.*

Many patients had prodromal symptoms, i.e. subtle signs or symptoms before an established 'stroke' occurred. These were ignored, causing a delay in seeking help:

"The Tuesday beforehand I had an episode of double vision while driving, and I had to close 1 eye to focus better. That lasted for around 20 seconds I'd say and then it went back to normal again then" – P9.

"…My runners just kept getting caught (on the tiles) as if I was about to trip myself up...it seemed to happen quite a few times and it's kind of like...what am I tripping on?" – P4.

*"We bought a new car myself and the wife, one of these electric petrol hybrid things, a Yaris. I took one drive in it, and I just looked left and I said to myself there's more of a blind spot on this car than there was on the last car. And two weeks later I turned in the entrance and **** me I touched the left-hand side of the car off the wall. Cost 750euros to fix it" – P3.*

DISCUSSION

This is the first known qualitative study of PCS patients' experiences of their symptoms and shows large variation in their presentations. Many patients described unusual and subtle symptoms that were difficult to interpret including disturbances of balance, co-ordination, vision and perception, and were often not considered symptoms of a stroke. Therefore, the relevance of these findings highlights how PCS may be experienced and described by the patient before a clinical assessment is carried out.

The majority of patients (90%) in this study did not think that they were having a stroke, with only 50% seeking help immediately. The remaining 50% sought help between four hours, and four days later. Previous research has shown mixed results in the public's awareness of stroke symptoms, with hospitals showing increased public attendance at ED's for stroke in the immediate aftermath of a stroke campaign (e.g. FAST campaigns) but not sustaining this in the long term (Mellon et al., 2014).

A survey on the Irish populations awareness of stroke symptoms published in 2023 showed a low public awareness of the 'FAST' signs of a stroke. The survey of over 1,000 people showed that facial weakness is the most commonly recognized symptom but only recognized by 35% of people. Slurred speech was recognized by 16%, whereas arm weakness or numbness was recognized by 14%. Only one in ten people knew what all four FAST letters stood for (IPSOS, 2023; Shannon, 2023). These results are extremely worrying, because if a population is not aware of the signs of the most common type of stroke i.e. anterior stroke, then it must be assumed that they have very little knowledge of the more subtle signs of posterior stroke. This lack of awareness is also echoed in the medical community, where 37% of PCS were missed in the ED in a retrospective chart review (Arch et al., 2016) and 67% were missed by paramedics in a vignette study (Devlin & Bury, 2023). The most recent Irish National Audit of Stroke (INAS) report from the National Office of Clinical Audit (NOCA) shows that 43% of stroke patients did not arrive at hospital within 4.5 hours of stroke symptom onset (McCormack et al., 2024). While the document reports on stroke as a whole rather than its subsets (i.e. anterior versus posterior stroke), the current study may offer some insights into the difficulties of PCS patients recognizing their symptoms and the subsequent delay in their help seeking behavior. As PCS patients represent approximately 20-25% of ischemic strokes (Floßmann & Rothwell, 2003; Merwick & Werring, 2014), they may represent a significant proportion of the patients that arrive late to hospital and therefore outside the window for potential treatment and future research should examine this group.

The participants in this study did not present their experiences as isolated textbook symptoms, but instead described complex combinations of balance issues, visual disturbances, changes in bodily function, speech issues, and a sense that something was wrong but couldn't put their finger on it. This may help explain in part why PCS can be so challenging to detect in the prehospital environment. The ten patients here reported 20 different symptoms, highlighting the large variation in patient presentation, even among a small cohort. Here, the top four reported symptoms were loss of balance, unable to walk unaided, and dizziness, while visual disturbance and headache tied for 4th. The New England Medical Center Posterior Circulation Registry, consisting of 407 PCS patients, reports the top four symptoms as dizziness, unilateral limb weakness, dysarthria and headache (Searls et al., 2012). The registry reports gait ataxia as the second most common sign, but it is described as a symptom here as it is self-reported. Therefore, while this is a small study size, results are somewhat comparable to this large registry in comparison.

It is important to note that no single patient reported only one symptom in isolation in this study. For example, the patient with the lowest number of symptoms described having dizziness, loss of balance, and unable to walk unaided. However, caution must be taken if extrapolating these results to broader populations, given the very small sample size of this group. For example, isolated dizziness with no other neurological findings presents a diagnostic challenge for physicians in recognizing a peripheral cause (e.g. vertigo, labyrinthitis, Ménière's disease) as opposed to a central cause (e.g. stroke, multiple sclerosis, brain tumor) (Kerber & Newman-Toker, 2015). A recent study found that acute stroke was found in 55/1239 patients (4.5%) with isolated dizziness, and recommended further neuroimaging workup is needed in high-risk patients - patients > 65 and a history of stroke were the strongest predictors - but associations were also found in those with known stroke risk factors such as hypertension and atrial fibrillation (Kim et al., 2021). However, other studies have reported higher incidences of isolated dizziness caused by a stroke at 11% (Doijiri et al., 2016) and 28% (Hu et al., 2025) and so extreme caution must be taken when dealing with these patients, especially those with risk factors for stroke. Therefore, dizziness/vertigo symptoms 'plus' other neurological findings increase the likelihood of stroke, and caution should be exercised in those with isolated symptoms with accompanying risk factors.

While many PCS patients can be 'FAST negative' (Gulli & Markus, 2012; Jones et al., 2021; Rowe et al., 2020), 30% of this study population described symptoms present in the FAST test (20% speech problems, 10% arm weakness). It is important to note that many participants described arm and/or leg paraesthesia (e.g. numbness, tingling, squeezing sensations) and also leg weakness, however these points are not traditionally taught or examined as part of the FAST exam, as FAST was originally developed to only test arm weakness and not the lower limbs, with no test for paraesthesia included (Harbison et al., 2003). Therefore, paramedic education may benefit from including both upper and lower limb paraesthesia as part of their clinical assessment to aid in stroke detection.

The results of this study share similarities in Andersson et al.'s study (2024), including patients having a distorted sense of reality where stationary objects were moving or altered (oscillopsia), and physical disturbances such as limb numbness, tingling, loss of coordination described as clumsy fingers, and a need for support such as holding on to a wall or furniture, with patients here describing similar experiences. Whereas Anders-

son's study did not explore the subtypes of stroke, the current study may propose that a proportion of their patients were experiencing posterior circulation strokes due to the similarities in their presentation.

Similarly to Andersson, this study had a repeated theme of patient's needing extra support to walk: "I was hanging onto the wall, I had to go from chair to chair, I was holding onto the car". As Paramedics deal primarily in acute undifferentiated patients and are the first point of contact and entry into the healthcare system for almost 80% of stroke patients (C. I. Price et al., 2013), being vigilant to the patient who acutely needs aids to walk, such as holding on to walls or furniture, may prompt the practitioner to investigate further for signs and symptoms of stroke. These findings suggest that paramedic education may benefit from exploring an assessment of the patient's ability to walk unaided (where safe to do so) in such cases. In the absence of other causes like hypotension, infection and diabetes for example, the acute inability to walk may lead the paramedic to consider PCS as a differential diagnosis prehospital.

60% of this cohort experienced prodromal symptoms prior to the onset of their stroke. The most prevalent symptoms included vision changes, headache and loss of balance/coordination. In retrospect, these patients may have been suffering from spontaneous episodic vestibular syndromes (EVS) in the week(s) leading up to their stroke. This is described as transient dizziness lasting seconds to hours, but rarely days, and often accompanied by nausea, nystagmus and sudden falls (Kaski et al., 2025). A cross-sectional study on vestibular syndromes presenting to the ED showed that EVS was caused by a TIA in 10% of cases, whereas acute vestibular syndrome (AVS, continuous dizziness plus symptoms from days to weeks) was more likely to have a stroke diagnosis at 25% of patients (Comolli et al., 2023). As TIA's are a significant risk factor for future strokes (Hejazian et al., 2025; Khan et al., 2025), paramedics should be vigilant of prodromal symptoms in their patient's history that may be undiagnosed episodic vestibular syndromes, to heighten their suspicion of PCS.

At the time of writing, new education standards have recently been introduced by the Irish Prehospital Emergency Care Council (PHECC), with the most recent paramedic competency framework including posterior circulation stroke education for paramedics for the first time (Prehospital Emergency Care Council, 2025). Formal education on PCS for paramedics will inevitably increase awareness and subsequent recognition, but future research exploring the public's help seeking behavior for stroke would be highly beneficial.

LIMITATIONS

This study, while rich in data, was small in size with only ten patients, and only represented 18.5% of the PCS population that presented to these two stroke hospitals in the study period. As such, thematic saturation was not achieved, and a larger sample size would be needed to achieve this. As the study period was only four months, analysis of seasonal variations was not possible. As a qualitative study, there is also a risk of bias from the patient (recall bias) and the primary investigator as a practicing Advanced Paramedic (confirmation bias). These were mitigated somewhat by having the participants take part within a four-week period to help memory recall and reduce bias, and having the PI complete a statement of reflexivity and regularly review with the wider research

team. This study should not be interpreted as identifying diagnostic criteria for PCS, but rather an explanatory account of how a small sample experienced their symptoms which may help inform future education of paramedics. Of note, many potential participants were excluded from the study as they were too unwell to participate, indicating that this sample population consisted of the healthiest patients available to take part and therefore excluded those with more severe presentations and deficits.

CONCLUSION

The posterior circulation stroke patients in this study suffered a large variety of symptoms, many of which went unnoticed both by the patient and their surrounding families. 90% of patients did not think they were having a stroke, and 60% had prodromal symptoms preceding the event. Qualitative analysis created three main themes of physical disturbance, visual and spatial disturbance, and dismissal, highlighting the difficulties in both recognizing PCS and seeking help for it. Future research should employ larger sample sizes, and focus on public awareness of PCS symptoms, and its further integration into Paramedic education to ensure prompt prehospital recognition and subsequent management.

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APPENDIX

Semi-Structured Interview Questions

Introduction

- Introduction and general outline of study
- Consent and written consent gained
- Resources available if recalling events becomes difficult.

Main Questions

- What were you doing when your stroke occurred?
- What was it like when it happened? Can you describe it to me?
- Did you think you were having a stroke at the time?
- How long did it take you to call for help?
- Did you call for an ambulance or make your own way to hospital?
- Were you well in the week leading up to this?
- Is there anything you'd like to add?

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RESEARCH REPORTS

SUPPORTING PERSONS WITH SENSORY NEEDS THROUGH THE CREATION AND IMPLEMENTATION OF BEARY CALM BAGS IN CONJUNCTION WITH A LOCAL FIRE DEPARTMENT

Alexis M. F. Morin, OT, OTD, MOT*[1]; Erin K. Wells, OT, OTD, MSOT[1]

Author Affiliations: 1. Western New England University, Springfield, MA, USA.

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**Corresponding Author:* alexis.morin@wne.edu

ABSTRACT

First responders represent the initial point of contact within the healthcare system, playing a vital role in providing timely care. Sensory dysregulation and communication challenges can affect individuals across the lifespan, often resulting in barriers to accessing and receiving effective care. This pilot study examined the implementation of BEary Calm Bags, sensory regulation bags containing various sensory and communication tools created by occupational therapists, for use by first responders during emergencies with individuals with these challenges. First responders received educational interventions focused on supporting people experiencing sensory and/or communication needs during emergencies. Quantitative and qualitative data were collected from eight first responders to determine perceptions regarding use, effectiveness, and sustainability of the bags. Approximately 87% of participants found the bags beneficial, with 75% using them multiple times. These findings suggest the BEary Calm Bags may support first responders in moving towards delivering more equitable, patient-centered care, while helping to reduce barriers related to healthcare inequities.

INTRODUCTION

People with disabilities are more likely to experience healthcare inequities and are at a greater risk of developing physical and mental health conditions such as stroke, diabetes, obesity and depression (Centers for Disease Control and Prevention, 2024; Clemente et al., 2022; Iezzoni & Agaronnik, 2020; World Health Organization, 2023). Common barriers individuals with disabilities encounter when accessing healthcare services include communication challenges with healthcare professionals, insufficient resources, a lack of training among healthcare professionals, and stigmatization and negative attitudes among healthcare workers. Individuals with sensory processing, and emotional regulation challenges encounter similar barriers to accessing healthcare as people with other conditions, but they also experience obstacles including difficulties with emotion regulation, and sensory processing (Raymaker et al., 2017). Emotion regulation challenges can lead to elevated responses to stressors in healthcare environ-

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ments, resulting in communication barriers such as difficulty expressing pain, concerns, and needs. Sensory processing difficulties, such as hypersensitivity to light, sound, or touch, can also contribute to an overwhelming and inaccessible healthcare experience. In addition to individuals with Autism Spectrum Disorder (ASD), people across the lifespan who experience sensory processing and/or communication difficulties because of a mental health condition, neurocognitive condition (e.g., dementia), and/or a sensory processing disorder (SPD) may also encounter significant difficulties during emergencies due to similar barriers that individuals with ASD experience. These create substantial obstacles to receiving adequate care and can contribute to inequities in their healthcare access and quality, which results in the need for interventions to address this gap in care and to improve outcomes (Raymaker et al., 2017).

Obstacles frequently occur during the prehospital phase. Individuals may experience heightened sensory stimuli when receiving care from emergency medical services (EMS) due to any of the following factors: flashing lights, loud sirens, touch from first responders during interventions, confined spaces, and chaotic surroundings. Limited communication techniques by first responders and their lack of training on how they can best assist populations who experience difficulty regulating this sensory input can lead to sensory and emotional dysregulation among individuals, ultimately hindering the provision of appropriate and effective care (Cheung et al., 2019). Safety and well-being can be compromised in this situation and demonstrate the critical need for educational interventions for first responders focused on communication strategies and tools to support vulnerable populations with sensory processing difficulties. Developing and implementing interventions to target these areas would also assist with reducing healthcare inequities and barriers and could promote inclusivity in healthcare while improving the quality of care (Cheung et al., 2019; Lombardi et al., 2024).

LITERATURE REVIEW

Overview of Sensory Processing

Sensory processing is a neurological process focused on how individuals gather information about their world including their environment and bodies (Brown et al., 2019). It involves the way in which an individual's brain receives, organizes, and responds to sensory input during their daily interactions from all senses, to facilitate effective engagement and interaction within both physical and social environments. Sensory processing involves several steps and begins with the nervous system detecting sensory stimuli or inputs. During this first step, some individuals may be hyper- or hyporesponsive, demonstrating increased or decreased sensitivity to a given sensory stimulus. Step two involves the brain recognizing or clarifying a particular stimulus while step three is when meaning is assigned to the information/input received. Finally, an unconscious or conscious behavioral response occurs, such as covering ears due to the discomfort of loud noises or a slight body jerk triggered by an intense and sudden sound (Brown et al., 2019). Sensory dysregulation is considered a general term referring to a person having difficulty regulating their sensory experiences and can lead to an individual displaying over or under-responsiveness to sensory stimuli. Sensory dysregulation may present with behavioral responses that include emotional distress, withdrawal, and communication challenges. Sensory modulation is a critical component of sensory processing and is a person's ability to self-regulate their reactions to sensory input in an appropriate man-

ner (Brown et al., 2019; Champagne, 2011; May-Benson & Schaaf, 2015). Sensory modulation difficulty is a specific type of sensory dysregulation where a person has challenges with appropriately filtering and adjusting to sensory input, resulting in an over- or underreaction, that others may find typical.

Populations At-Risk for Sensory Dysregulation

Sensory modulation is often a challenge for children and adults with SPD and/or mental health conditions such as attention-deficit-hyperactivity disorder (ADHD), ASD, post-traumatic stress disorder (PTSD), developmental trauma, mood disorders, schizophrenia and schizoaffective disorders, intellectual and/or developmental disabilities, obsessive-compulsive disorder, and neurocognitive disorders (Brown et al., 2019). There are similarities in how these individuals may experience and present with sensory modulation difficulties; however, various conditions have slightly different presentations. For example, when children or adults with ADHD experience sensory modulation difficulties, they have difficulty attending to pertinent information while also filtering out irrelevant sensory stimuli, which can lead them to display excessive movement,noise or avoiding situations. Persons with ASD may also present with variable responses to sensory stimuli such as actively seeking sensory input or displaying hypersensitivity or hyporesponsivity throughout their daily routine. Children and adults with histories of developmental or early childhood trauma such as abuse or neglect may have difficulty filtering and adjusting to sensory input. This is largely due to the experience of trauma impacting early childhood brain development, resulting in difficulty with self-regulating. Difficulties with sensory modulation may present as hyperarousal or hypoarousal. They may also have triggers that are related to sensory input that can lead to over- or underreaction and may present as being easily overwhelmed, shutting down, demonstrating strong emotional reactions, or displaying hypervigilance. This presentation is similar to individuals who have PTSD. Adults with schizophrenia can also present with sensory modulation difficulties, primarily with determining between important and unimportant sensory information in their environment, which can lead them to feeling confused, overwhelmed, or appearing distracted. In some instances, this may lead to behaviors such as social withdrawal. Mood disorders can also be accompanied by sensory modulation difficulties with individuals potentially being more sensitive to sensory input when experiencing a depressive episode or seeking sensory stimuli during mania (Brown et al., 2019).

Role of Occupational Therapy

Occupational therapy is a holistic and client-centered healthcare profession that works with people across the lifespan to maximize their engagement in meaningful occupations, which are activities people want and need to do in daily life (American Occupational Therapy Association (AOTA), n.d.; AOTA, 2020). Occupations may include but are not limited to activities of daily living (e.g., dressing, feeding, bathing, hygiene), work, education, sleep and rest, leisure, socialization, instrumental activities of daily living (e.g., household tasks, money management, driving or using community transportation), play, and health management (e.g., coping and managing mental and/or physical health conditions, attending medical appointments) (AOTA, 2020). Occupational therapy practitioners (OTPs) assist people with living "life to its fullest" by promoting their health and enhancing their ability to manage and cope with an injury, disability, or illness (AOTA,

n.d.). OTPs also aim to enhance individuals to live their lives with greater independence (AOTA, n.d.; National Library of Medicine, 2024). Within occupational therapy's broad scope of practice, sensory processing and modulation are areas OTPs have expertise in and are skillful in addressing (AOTA, 2020). OTPs utilize a holistic approach, which entails adapting a person's environment and/or task to best meet the unique needs of an individual, to promote a person's level of independence during daily activities (AOTA, n.d.; AOTA, 2020).

OTPs recognize that difficulties in sensory processing and modulation can impact performance and engagement in meaningful occupations. OTPs are qualified and trained in how to appropriately assess and address sensory processing difficulties (AOTA, 2020). They utilize evidence-based interventions and facilitate skill development, to support an individual's ability to function optimally in their environment, during daily tasks and situations. This includes providing tools and skills to effectively interpret and respond to sensory stimuli. OTPs utilize a client-centered and holistic approach to consider how sensory processing difficulties may impact a person's daily function and overall quality of life. Considering OTPs' expertise in this area, they are key professionals in developing and integrating sensory-based interventions and programming. They utilize evidence from the existing body of literature and clinical expertise while also incorporating sensory processing theories they are well versed in to develop tailored interventions for individuals and populations in various settings with the goal of maximizing their daily functioning and overall quality of life.

Sensory Dysregulation During Emergency Situations & Evidence-Based Interventions

Emergency situations for pediatric and adult populations can be overwhelming and potentially lead to unproductive and/or unsafe interactions between the patient and the healthcare provider, if there are no tools or strategies to support their interactions. Examples of sensory stimuli people may encounter may include the following: bright flashing lights, equipment alarm sounds (e.g., buzzing, beeping, or alert sounds), quick movements that can be disorienting (e.g., ambulance moving fast, turning and stopping abruptly), strong odors (e.g., from disinfectants, medical supplies, bodily fluids), sudden temperature changes (e.g., opening of doors), loud sirens, and physical contact from first responders during interventions and procedures. Persons with sensory modulation difficulties, may experience increased distress, discomfort, and challenges with self-regulation when they encounter such unexpected stimuli and sensory demands. While sensory dysregulation alone can lead to communication challenges, several of the conditions discussed previously can also result in communication difficulties, all of which may hinder their ability to express needs, understand instructions, or effectively engage with first responders or healthcare providers.

To assist with meeting the needs of persons with sensory processing difficulties, sensory interventions have been primarily employed in emergency departments. Modifying emergency departments to create a sensory-friendly environment has been successful in meeting patients' needs during stressful events (Wood et al., 2019). Sensory aids have also improved the healthcare experience for patients and caregivers within emergency departments (Roy et al., 2024).

First responders' limited training in strategies to effectively interact with patients with communication and/or sensory processing difficulties can hinder the provision of appropriate and effective care (Cheung et al., 2019). Despite this critical need, there are few studies within the current body of literature focused on sensory interventions during prehospital care. Ben's Blue Bags is one example of a successful program that has been implemented prehospitally for first responders to utilize during sensory and communication obstacles. Each bag included sensory and communication tools such as noise-reduction headphones, a dry erase board for communication needs, a visual for indicating pain levels and location, and various sensory tools (e.g., stress balls, bendable bracelets, pop-it fidgets, fidget spinners, and Rubik's cubes) (Lombardi et al., 2024). Sensory and communication aids have been effective in improving prehospital care, allowing first responders to provide tailored and successful care to individuals with unique sensory needs in emergency situations (Lombardi et al., 2024; Shah et al., 2020). Developing and implementing similar interventions to target sensory and communication obstacles could assist with reducing healthcare inequities and barriers while also promoting inclusivity in healthcare and improving the quality of care (Cheung et al., 2019; Lombardi et al., 2024). Providing first responders with education on sensory processing and communication challenges, and tools they can utilize to assist with such obstacles may assist with addressing this current gap in care.

STUDY PURPOSE

Based on the current literature, this study sought to provide training for first responders and sensory regulation tools for populations who present with sensory dysregulation during an emergency response within a local community, to address this gap in care. The BEary Calm Bags (Morin & Wells, 2025) were established and developed as a pilot project through a community-based collaboration titled, BEary Calm Bags. These bags included various sensory regulation tools and communication aids to be utilized during emergency responses by one fire department in Massachusetts. The objective of this pilot program was to determine first responders' perceptions regarding the use, effectiveness, and sustainability of the BEary Calm Bags during emergency responses.

METHODS

This pilot study includes program development and creation of the BEary Calm Bags followed by piloting the implementation of the bags. This pilot study was approved by the affiliated university's Institutional Review Board (IRB). One of the researcher's is related to a member of the department where the program was piloted.

Program Development

Initial approval and financial support of this pilot project proposal were granted by the Department Chair and Program Director of the Entry-Level Doctor of Occupational Therapy (OTD) Program at the university where the researchers were employed. The budget consisted of potential items that would be placed in the BEary Calm Bags and included the cost for 12 total bags.

Following the Department Chair and Program Director's approval and allocation of funding for this project, a local fire department in Massachusetts located in a suburban area was identified as a potential community site to partner with. Communication and

was initiated with the fire department's chief, assistant chief, and EMS lieutenant to discuss collaboration and the project proposal. Although initial funding to pilot the 12 bags was to be provided by the occupational therapy department, it was explained that this project required approval from the university's IRB, as data collection would be conducted to support future grant applications to aid in ensuring the project's sustainability. The fire department's personnel were all in agreement with the project proposal and receptive to implementing the pilot program to support first responders' delivery of care to community members.

Three cohorts of OTD students within the program were informed of the opportunity to collaborate with the primary investigators on this pilot project. Information explaining the purpose of this project and the specific areas students could assist with was sent via email. Students were encouraged to contact the primary investigators if they were interested in pursuing this opportunity, which led to three students working closely with the primary investigators. The students were tasked with developing visual aids with communication and sensory tools for first responders to utilize. Visual aids went through several revisions following researcher feedback. A 10-minute video and written guide were developed in collaboration with the researchers to train first responders on the following: conditions associated with sensory and/or communication difficulties, the purpose of each tool to be provided within the BEary Calm Bags, when they might offer and utilize each tool, and how the items connect to sensory modulation and communication. The training video and written guide also outlined safety precautions of each item to enhance first responders' knowledge of appropriate uses of each tool.

Implementation of BEary Calm Bags

The primary investigators provided the EMS administration with the training tools to disseminate to first responders and ensure completion of the training. All items within the bags were applicable to pediatric and adult populations. A total of 12 BEary Calm Bags were distributed to one local fire department located in a suburban area in Massachusetts across the department's three ambulances. When patients arrived to the emergency department, they were able to keep the items within the bags for their continued personal use in the future.

The EMS Lieutenants encouraged any first responder who utilized or attempted to implement any item within the bag to complete the informed consent and the researcher-generated post-implementation survey. The survey was distributed to first responders via email six-weeks after the initial implementation of the BEary Calm Bags. Qualitative and quantitative data were collected in the survey to determine the frequency of items utilized within the bag, the overall effectiveness of the bags during patient interactions, and any recommendations to improve the quality and contents of the bags.

Data Analysis

The quantitative data were analyzed using descriptive statistics in Microsoft 365 Excel. The two investigators independently analyzed the raw qualitative data to generate initial keywords and codes. The investigators then discussed and compared their codes to develop relevant themes, to assist with decreasing biases and enhancing the accuracy of the results. Discrepancies related to codes and themes were resolved through discussion

between the investigators. Final themes and supporting quotes were determined collaboratively.

RESULTS

Quantitative Results

Eight first responders consented to participate and completed the survey. The bags were used two or more times by 75.0% of respondents (n = 6) in the six-week span. Only one first responder had not yet used the BEary Calm Bag during an emergency response during this period. Please see Table 1 below for a visual depiction of how frequently first responders utilized the BEary Calm Bags with patients. Of the first responders who had used the BEary Calm Bags, 87.5% (n = 7) indicated "yes" the BEary Calm Bags were beneficial during an emergency response. The most frequently used items from the bags were the pop-it fidgets (n = 6), followed by the pinwheels (n = 3), sunglasses (n = 2), and headphones (n = 2). Please see Figure 1 below for an illustration of additional details regarding first responders' use of the tools included in the BEary Calm Bags.

Number of Times Used	Number of Participants
0	1
1	1
2	3
3	2
4	1

Table 1. Frequency of BEary Calm Bag usage among first responders.

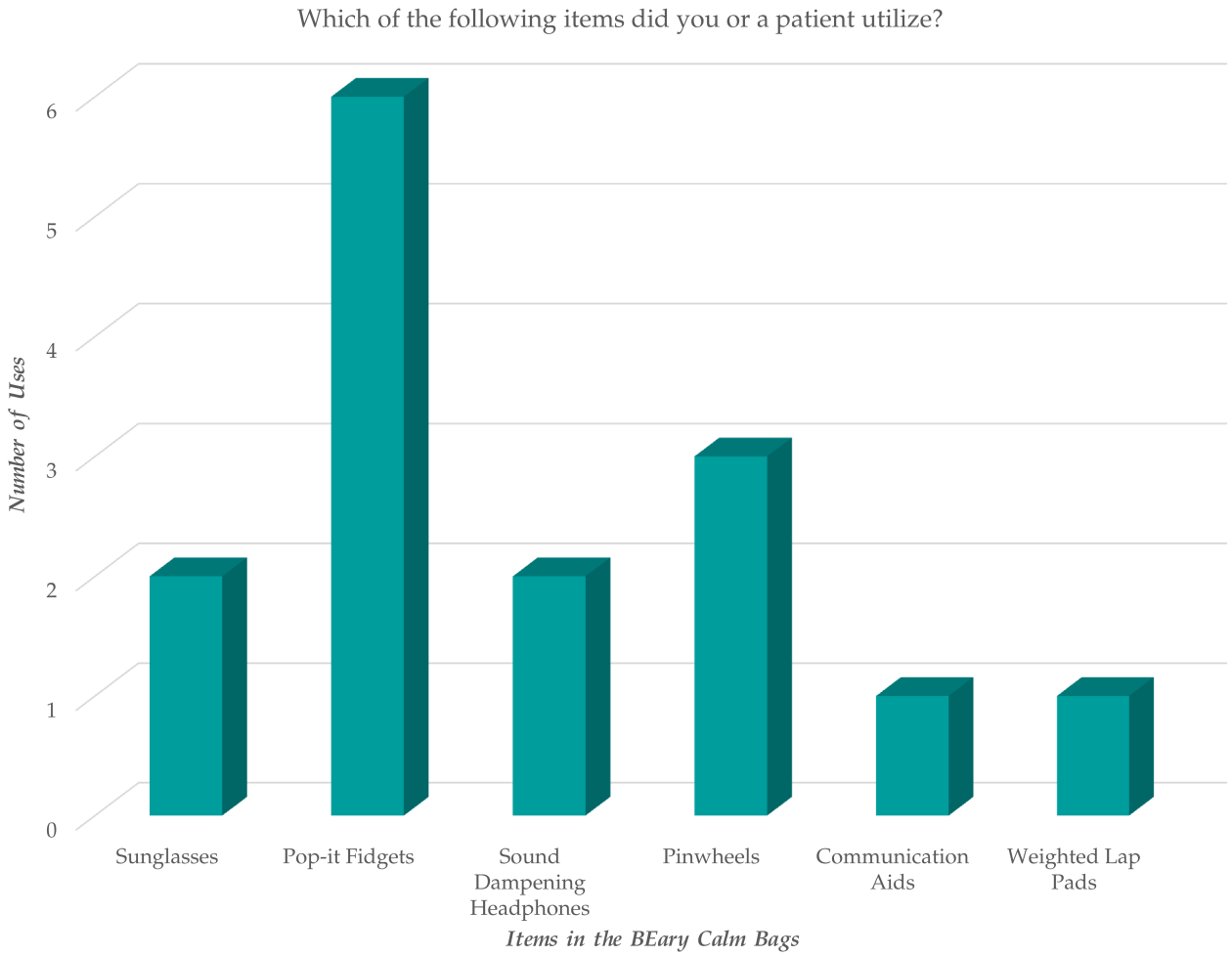


Figure 1. Frequency of item usage in BEary Calm Bags among first responders.

Qualitative Results

Qualitative data analysis garnered two central themes from the open-ended responses. First, the BEary Calm Bags allowed for better patient care. One participant indicated the items, such as the communication aids, "allow [sic] us to better understand what is going on with a patient who may not be able to communicate verbally." Further, calming and distracting was identified as the second theme. Several respondents commented on how the BEary Calm Bags assisted in calming patients and were particularly helpful in distracting the patients when performing critical assessments and interventions. Examples of supporting quotes for the themes can be found below in Table 2.

Theme	Sample Quotes
Allows for Better Patient Care	• "Distracts the patients from what is going on and allows for a more in-depth assessment." • "The communication sheet really help get a sense of the amount of pain they are in, and also allows us to better understand what is going on with a patient that may not be able to communicate verbally." • "Allowed EMS to perform necessary interventions." • "The kits help us provide care when dealing with specific populations of our patients during an over stimulating experience such as a medical emergency."
Calming and Distracting	• "It helps calm a patient." • "Calmed the patient at the time." • "Distracts the patients from what is going on."

Table 2. Thematic analysis of data.

When asked to identify the item(s) first responders found most useful for patients, they commonly cited the pop-it fidgets as particularly beneficial. Several respondents also noted the overall usefulness of all items included in the BEary Calm Bags. In addition to the pop-it fidgets, weighted lap pads, pinwheels, headphones, and communication aids were also mentioned as valuable supports during EMS patient interactions. Finally, first responders also provided feedback on improving the quality and items within the bags. They expressed that the variety of items included was valuable, as it provided an opportunity for patients to select tools that best suited their needs.

DISCUSSION

This pilot study aimed to determine first responders' perceptions of the BEary Calm Bags, including the frequency of bag and item utilization, their overall effectiveness during patient interaction, and recommendations for enhancing the quality of the bags to support sustained use in the prehospital care phase. Six out of the eight participants had utilized the BEary Calm Bags at least two or more times, and seven out of the eight participants identified the bags as valuable during an emergency response.

The results of this pilot program indicate that the BEary Calm Bags helped support sensory regulation of patients, enabling first responders to provide effective interventions during emergency response situations. This overarching finding aligns with existing literature on the benefits of incorporating sensory and communication aids to enhance prehospital care and to deliver care tailored to individuals with diverse sensory needs during emergency situations (Lombardi et al., 2024; Shah et al., 2020). Although this study focused specifically on the use of sensory and communication aids during prehospital care with first responders, prior research demonstrates that sensory and com-

munication interventions also enhance healthcare experiences for patients and their care partners in emergency department settings (Roy et al., 2024). This similarity suggests that addressing sensory needs across different phases of emergency care could contribute to overall enhancements in patient outcomes and satisfaction.

Sensory sensitivity is not confined to one demographic and can occur across the lifespan. It is also a highly individualized experience, and failure to adequately address people's sensory needs can create substantial barriers to access and delivery of quality care, negatively impacting their healthcare experiences. First responders have limited training in supporting individuals experiencing sensory dysregulation and communication challenges, which may impact their ability to deliver effective care (Cheung et al., 2019). Equipping first responders, who are often the initial point of healthcare contact, with this training addresses a critical gap in care related to equitable access and quality of care for people with diverse sensory and communication needs. This aligns with literature emphasizing that educational interventions focused on addressing sensory and communication challenges can enhance equitable access and quality of care (Cheung et al., 2019; Lombardi et al., 2024). Incorporating sensory and communication tools during patient interactions also aligns with broader efforts in healthcare and supports the objectives of the Healthy People 2030 framework by aiming to reduce inequities and obstacles experienced by patients with diverse disabilities (Office of Disease Prevention and Health Promotion, n.d.).

LIMITATIONS

Although this pilot program yielded positive results, there are several limitations to this study that may have impacted the outcomes. The first limitation is the relatively small sample size, limited to participants from a single department located within one geographic location in Massachusetts. This may restrict the generalizability of the findings. The small sample size was further limited by difficulty collecting extensive data. This department has a high EMS call volume and first responders are responsible for immediate call documentation, which limits their opportunities and access to monitor their emails regularly. This may have impacted their ability to readily access the consent and survey link to complete following each use of the BEary Calm Bag. Additionally, the training was provided via asynchronous materials to offer flexibility and accessibility. However, this may have led to decreased buy-in and carryover from the first responders. Participants must fulfill other extensive state and department-mandated training requirements, which can further restrict their available time to complete additional training. Advocating for and integrating sensory tools into standard emergency protocols may assist with better training adherence and support sustained use of the bags. It would also be beneficial to continue data collection beyond the six-weeks to determine the efficacy of long-term use and implications of the BEary Calm Bags.

IMPLICATIONS

Several key implications for clinical practice and research from this pilot project emerged. For OTPs and other healthcare practitioners working to support individuals who may experience sensory dysregulation or communication difficulties in the community, this project indicates the potential for utilizing and expanding these sensory-informed practices across other areas and settings. For example, this program could be

expanded to include additional emergency response and care settings such as other fire and police departments, emergency departments, physicians' offices, residential group homes. The findings also display the critical value and necessity of standardized training protocols for EMS first responders. Furthermore, it would be beneficial to deliver training materials both synchronously and asynchronously, as opposed to solely asynchronous delivery, which was a limitation of the current project. There are implications for future research based on the initial results of this pilot project, which include the need for replication of the project with longitudinal data collection and analysis. Based on the qualitative data collected, it may be beneficial to collect additional data on how sensory-based intervention initiatives foster inclusivity and accessibility within emergency response systems and promote equity in healthcare.

CONCLUSION

Results of this pilot program revealed that community-based initiatives such as the BEary Calm Bags may provide meaningful assistance to first responders during an emergency response, by calming and distracting a patient experiencing sensory dysregulation. The findings from this pilot initiative highlight the potential for incorporating sensory and communication tools to reduce healthcare inequities and barriers, thus promoting inclusive and equitable care regardless of patients' sensory needs. Future opportunities include expanding this type of initiative into other potentially dysregulating community-based settings such as emergency departments, physician offices, or residential group homes. The limitations in this study also result in the need for additional research on this topic from a longitudinal standpoint. However, it is important to emphasize the value that the BEary Calm Bags can have, based on preliminary data on improving healthcare equity and minimizing barriers for individuals with various sensory needs.

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RESEARCH REPORTS

SLEEP DYSFUNCTION, ACCIDENTS, AND INTENT TO LEAVE AMONG EMERGENCY MEDICAL SERVICES PROVIDERS: A CROSS-SECTIONAL STUDY

Celia Sporer, PhD, LMHC, EMT-P*[1]; Daniel Armstrong, DPT, EMT[1]; Jody Resko, PhD[1]

Author Affiliations: 1. City University of New York (CUNY) Queensborough Community College, Bayside, NY, USA.

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**Corresponding Author:* csporer@qcc.cuny.edu

ABSTRACT

Emergency medical services (EMS) providers operate under occupational conditions that carry substantial risk for sleep disruption and fatigue-related impairment. Extended shifts, overnight assignments, rotating schedules, and secondary employment are structural features of many EMS systems that consistently interfere with adequate sleep. The relationships among sleep quality, daytime sleepiness, sleep disturbance, occupational fatigue, fatigue-related safety outcomes, and workforce retention were examined among a cross-sectional sample of 254 EMS providers. Sleep quality was assessed using self-report measures, daytime sleepiness was measured using the Epworth Sleepiness Scale (ESS), and sleep disturbance was assessed using a sleep disturbance index derived from the Pittsburgh Sleep Quality Index (PSQI). Results indicated that poor sleep quality and fatigue were widespread: 63.7% of participants rated their sleep quality as bad or fairly bad, and 47.6% reported considerable or intense sleepiness while at work. Providers who reported fatigue-related driving accidents or near-miss incidents demonstrated significantly higher ESS scores than those who did not (M = 9.33 vs. 7.28, p = .001, d = 0.49). Regression analyses revealed that sleep variables explained limited variance in intent to leave, though work-related sleepiness approached significance as a predictor of turnover intentions in both models. Shift length emerged as a significant independent predictor of intent to leave EMS (p = .033), with providers working longer shifts reporting lower turnover intentions. Findings suggest that fatigue within EMS extends beyond wellness concerns to carry meaningful implications for operational safety and, to a lesser extent, workforce sustainability.

INTRODUCTION

Fatigue and sleep disruption are part of the operational culture of emergency medical services. Overnight tours, 24-hour shifts, mandatory overtime, and providers working for multiple agencies simultaneously make inadequate sleep not merely common but, in many systems, inevitable (Patterson et al., 2010; Patterson et al., 2012a). There is increasing awareness and recognition that this pattern carries consequences that extend well beyond individual discomfort, including consequences for clinical judg-

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ment, emergency vehicle operation, patient safety, and the long-term sustainability of an already strained workforce (Patterson et al., 2018a).

The EMS occupational context is distinct in ways that complicate simple comparisons to other healthcare or shift-work populations. Paramedics and EMTs are expected to transition rapidly from rest to high-acuity clinical response, often within seconds, during overnight hours when circadian physiology is least supportive of alertness (Boivin & Boudreau, 2014). Unlike hospital-based providers working within structured clinical environments, EMS personnel operate in uncontrolled field settings where scene safety, emergency driving, and real-time treatment decisions occur simultaneously and under pressure. The physiological consequences of fragmented sleep and circadian disruption, including impaired reaction time, reduced sustained attention, degraded working memory, and compromised executive function, directly impacting skills that are foundational to safe prehospital care (Alhola & Polo-Kantola, 2007; Lowe et al., 2017).

Despite this, fatigue within EMS has historically been treated as an occupational norm rather than an occupational hazard. Survey research conducted across EMS populations has consistently documented elevated rates of poor sleep quality, excessive daytime sleepiness, and clinically significant fatigue (O'Brien et al., 2025; Patterson et al., 2010; Patterson et al., 2012a). What is less well understood is how these conditions translate to operational outcomes, particularly fatigue-related driving incidents, and whether sleep disruption contributes independently to workforce instability beyond the better-studied contributors of burnout, compensation dissatisfaction, and organizational stress (Crowe et al., 2018; Crowe et al., 2020).

This study sought to address this gap by examining a range of sleep-related and occupational variables among a sample of EMS providers. Specific attention was directed toward the relationship between daytime sleepiness and fatigue-related motor vehicle accidents or near-miss driving events, the differential effects of shift length and nontraditional scheduling on sleep outcomes, and the degree to which sleep variables predict intent to leave one's current employer or the EMS profession entirely.

Shift Work, Circadian Disruption, and the EMS Operational Environment

Shift work is widely recognized as a major contributor to sleep disruption, particularly in EMS, where long hours, overnight shifts, and unpredictable schedules are common (Barth et al., 2022; Boivin & Boudreau, 2014). Overnight and rotating schedules interrupt circadian rhythmicity in ways that are not fully remediated by daytime sleep, which tends to be shorter, lighter, and more fragmented than nocturnal sleep (Boivin & Boudreau, 2014). For providers working consecutive extended shifts or holding secondary EMS employment, the opportunity for physiologic recovery between work periods may be genuinely inadequate (Patterson et al., 2015; Rivard et al., 2020).

Extended shift structures, 12- and 24-hour tours in particular, introduce additional concerns specific to within-shift fatigue accumulation (Patterson et al., 2018b; Patterson et al., 2012b). Even when agencies permit or designate rest periods during extended tours, the quality of sleep available in a station environment is frequently poor (Martin-Gill et al., 2018; Thielmann & Böckelmann, 2024). Dispatch tones, equipment checks, crew activity, and the anticipatory arousal associated with waiting for calls all compromise sleep continuity. Research has shown that interrupted and fragmented sleep can still lead to

significant fatigue and impairment, even when total sleep duration appears relatively adequate (Van Dongen et al., 2003).

These effects are not limited to overnight workers. EMS providers working rotating schedules often have little time to fully adjust between shift changes, leading to ongoing disruption of normal sleep patterns (Barth et al., 2022; Courtney et al., 2013). Day-shift workers who hold secondary employment during evening or overnight hours accumulate equivalent sleep debt through a different mechanism (Rivard et al., 2020). In high-volume urban systems, providers across all schedule types may complete a shift having obtained only fragmented, light sleep interspersed with repeated clinical activations throughout the night (Patterson et al., 2010).

Daytime Sleepiness, Fatigue, and Operational Safety

In EMS, excessive daytime sleepiness is particularly concerning because it has direct implications for patient care, provider performance, and public safety (Patterson et al., 2012a; Patterson et al., 2018a). Sustained attention, reaction time, situational awareness, and divided attention processing, all central to both clinical care and emergency vehicle operation, are among the cognitive functions sensitive to sleep loss (Alhola & Polo-Kantola, 2007; Lowe et al., 2017). Research consistently shows that as sleep restriction increases, performance progressively worsens (Lim & Dinges, 2010; Van Dongen et al., 2003). Importantly, individuals experiencing chronic sleep restriction often underestimate the degree of their own impairment, reporting levels of alertness that do not match objective declines in performance (Van Dongen et al., 2003).

Emergency vehicle operation under fatigue is a particularly underexamined area within the EMS literature. Drivers of emergency vehicles must process rapidly changing roadway environments, respond to other drivers' unpredictable behavior, navigate intersections against traffic signals, and make split-second decisions. During overnight hours when fatigue-related impairment is greatest this can be more problematic (Boivin & Boudreau, 2014; Dinges, 1995). Research involving commercial transportation workers and overnight shift employees has documented substantially elevated crash risk associated with sleep deprivation and excessive daytime sleepiness, yet equivalent data for EMS providers remain sparse (Lee et al., 2016). This gap is notable given that EMS-involved vehicle accidents carry consequences not only for crews but for patients in transport and the general public.

The Epworth Sleepiness Scale (ESS) has been widely used across occupational and clinical populations to assess propensity for daytime dozing across a range of sedentary situations (Johns, 1991). Higher ESS scores have been associated with impaired driving performance, increased accident risk, and occupationally significant lapses in vigilance (Dinges, 1995; Lee et al., 2016). ESS scores served as the primary measure of daytime sleepiness in this study and were examined in relation to both work-related functioning and self-reported fatigue-related driving incidents.

Sleep Disruption and Workforce Retention

EMS systems across the United States are confronting workforce instability of considerable scope. Recruitment pipelines have not kept pace with attrition, and the providers who do enter the field frequently leave within the first several years (Cash et al., 2024;

Powell et al., 2025). Understanding what drives these decisions and what distinguishes providers who remain from those who leave has become a practical priority for agency administrators and policymakers (Rivard et al., 2021).

Research examining EMS workforce retention has identified burnout, emotional exhaustion, leadership quality, compensation dissatisfaction, and scheduling demands as among the most consistent predictors of turnover intent (Crowe et al., 2018; Crowe et al., 2020; Powell et al., 2025). Sleep disruption has received comparatively less attention as an independent contributor to retention outcomes, despite its likely role in exacerbating the occupational strain that underlies each of these factors. A provider experiencing chronic fatigue may be less capable of emotional recovery between shifts, more susceptible to the cumulative effects of stress exposure, and more likely to perceive their working conditions as unsustainable (Patterson et al., 2015; Van Dongen et al., 2003).

Financial considerations, promotional opportunities, geographic factors, family demands, and organizational culture also contribute independently to retention decisions (Cash et al., 2024; Crowe et al., 2018), and the present study examined sleep-related variables as one contributor among many.

Purpose of the Present Study and Hypotheses

The primary aim was to examine relationships among sleep quality, sleep disturbance, daytime sleepiness, occupational fatigue, and fatigue-related safety outcomes among EMS providers. A secondary aim was to assess the degree to which sleep-related and scheduling variables were associated with workforce retention outcomes, including intent to leave one's current employer and intent to leave EMS entirely.

Five hypotheses guided the analyses. First, poorer overall sleep quality and lower sleep sufficiency were expected to be associated with greater daytime sleepiness, greater sleep disturbance, and increased work-related sleepiness (H1). Second, higher ESS scores and greater sleep disturbance index scores were expected to predict greater work-related sleepiness (H2). Third, providers reporting fatigue-related motor vehicle accidents or near-miss driving incidents were expected to demonstrate significantly higher ESS scores than those without such events (H3). Fourth, nontraditional scheduling and longer shift lengths were expected to be associated with poorer sleep and greater work-related sleepiness (H4). Fifth, sleep-related and scheduling variables were expected to be associated with intent-to-leave outcomes. (H5).

METHOD

Participants and Procedure

Participants were current EMS providers recruited using convenience sampling method. Recruitment occurred through professional EMS organizations, social media groups, and EMS agency distribution lists over a 4-month period in 2025. The final analytic sample consisted of 254 providers who completed an anonymous online survey distributed via SurveyMonkey. Participation was entirely voluntary. Electronic informed consent was obtained prior to survey participation, and all items were completed electronically in a single session.

Measures

Demographic and Occupational Characteristics

Participants provided demographic information including age, race and ethnicity, relationship status, educational attainment, household income, and student status. Occupational variables included certification level, type of EMS service, typical weekly EMS work hours, shift length, work schedule type, estimated annual call volume, whether respondents worked nontraditional schedules, and whether they held additional EMS or non-EMS employment.

Sleep Quality and Sleep Behaviors

Overall sleep quality during the previous month was assessed via a single self-report item. Participants additionally reported average nightly sleep duration, typical sleep latency, frequency of nighttime awakenings, and perceived overall sleep sufficiency. Additional items examined work-related sleepiness, sleep medication use, diagnosed sleep disorders, and use of positive airway pressure devices (CPAP). Participants were also asked to indicate whether they had ever experienced a motor vehicle accident or near-miss accident attributable to falling asleep while driving.

Daytime Sleepiness

Daytime sleepiness was measured using the Epworth Sleepiness Scale (ESS; Johns, 1991), in which participants rated their likelihood of dozing across eight common sedentary situations, including sitting and reading, watching television, and riding as a passenger in a vehicle. Higher total scores indicated greater daytime sleepiness. Internal consistency within the current sample was acceptable ($\alpha = .80$).

Sleep Disturbance

Sleep disturbance was assessed using a Sleep Disturbance Index derived from selected items adapted from the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989). The index included items assessing difficulty initiating sleep, nocturnal awakenings, nocturia, respiratory discomfort, coughing or snoring, temperature-related sleep disruption, nightmares, and pain-related sleep disturbances. Participants rated the frequency of each disturbance during the previous month, with higher scores indicating greater sleep disturbance. Because the complete seven-component PSQI scoring procedure was not used, this index should not be interpreted as the validated global PSQI score. Internal consistency of the Sleep Disturbance Index in the present sample was acceptable ($\alpha = .72$).

Intent to Leave

Workforce retention was assessed using two items examining participants' self-reported likelihood of leaving their current EMS employer within the next 12 months and leaving EMS entirely within the next 12 months. Response options ranged from very unlikely to very likely, with higher scores reflecting greater turnover intent.

Statistical Analysis

All analyses were conducted using IBM SPSS Statistics. Descriptive statistics were computed for demographic, occupational, sleep, and retention variables. Internal consistency

for the ESS and Sleep Disturbance Index (PSQI-derived sleep disturbance scale) was evaluated using Cronbach's alpha. Pearson correlations examined relationships among primary study variables. Independent-samples t-tests compared sleep outcomes between providers reporting and not reporting fatigue-related driving incidents, and between those using and not using sleep medications. One-way analyses of variance explored differences across scheduling and certification groups. Multiple linear regression examined whether sleep and scheduling variables predicted intent-to-leave outcomes after accounting for demographic and occupational covariates. Statistical significance was set at $\alpha = .05$ for all analyses.

Analyses were conducted using pairwise deletion. Consequently, sample sizes vary slightly across analyses because participants with missing data were excluded only from analyses involving those variables.

An a priori power analysis was not conducted. However, the final sample of 254 participants provided adequate statistical power to detect small-to-moderate effects for the primary analyses.

Ethics Approval

This study was reviewed and approved by the City University of New York (CUNY) University Integrated Institutional Review Board (UI-IRB) (Protocol No. 2019-0564), titled EMS Sleep Study: Examining Self-Reported Sleep Behaviors in EMS Providers. Participation was voluntary and anonymous. Electronic informed consent was obtained from all participants prior to completing the online survey.

RESULTS

Sample Characteristics

The sample comprised 254 currently certified EMS providers (Table 1), including 140 EMTs (55.1%) and 114 paramedics (44.9%). Service types represented included hospital-based EMS (31.5%), private ambulance (29.9%), municipal agencies (21.1%), fire-based agencies (12.4%), and volunteer services (5.2%). The majority of respondents reported working 12-hour shifts (51.8%), with smaller proportions working 8-hour (17.0%) or other extended configurations. Schedule types included overnight (28.9%), rotating (23.7%), day (22.9%), evening (8.7%), split (7.5%), and irregular or on-call arrangements (8.3%).

Occupational demands were substantial. Most respondents worked between 40 and 72 hours per week, and nearly half (49.4%) held more than one EMS-related position. Approximately 24.9% reported additional non-EMS employment. Urban or large-city settings accounted for approximately 50.6% of primary work locations. Call volume was high among many respondents: 30.7% reported responding to 20 to 29 calls weekly, 13.4% to 30 to 39 calls, and 10.6% to 50 or more calls per week.

The sample was predominantly White or Caucasian (81.9%), with Hispanic (12.4%), Asian (3.2%), and Black or African American (2.4%) participants also represented. Approximately 45.2% of respondents were married, and 24.4% held a bachelor's degree.

Regarding workforce retention, approximately 31.8% of participants reported being at least somewhat likely to leave their current employer within the next 12 months. A

smaller proportion, 15.4%, reported being likely or very likely to leave EMS entirely within the same period.

Sleep Quality and Fatigue Prevalence

Sleep-related difficulties were pervasive. Nearly two-thirds of participants (63.7%) rated their overall sleep quality as bad or fairly bad, while only 3.9% reported very good sleep quality. Perceived sleep insufficiency was similarly common: 58.1% described their overall sleep amount during the previous month as very insufficient or somewhat insufficient. Most participants reported averaging five to six hours of sleep per night at home. Nearly half reported routine sleep latencies exceeding 30 minutes, and the majority reported multiple nocturnal awakenings.

Work-related sleepiness was widespread, with 47.6% of respondents reporting either considerable or intense sleepiness during work hours in the prior month. Mean ESS scores were elevated at 7.89 (SD = 4.27), with approximately 24.0% of the sample meeting criteria for at least mild excessive daytime sleepiness. Fatigue-related driving concerns were common: 29.1% of participants reported having experienced a motor vehicle accident or near-miss incident attributable to falling asleep while driving. Additionally, 25.8% of respondents reported using medications to assist with sleep, and 21.7% reported a prior diagnosis of a sleep disorder.

Category	Characteristic	*n*	%
Certification Level	EMT	140	55.1
	Paramedic	114	44.9
Primary EMS Service	Hospital-based	79	31.5
	Fire-based	31	12.4
	Municipal	53	21.1
	Private	75	29.9
	Volunteer	13	5.2
Work Schedule	Day	58	22.9
	Evening	22	8.7
	Overnight	73	28.9
	Rotating	60	23.7
	Split shift	19	7.5
	Irregular/on-call	21	8.3
Relationship Status	Married	114	45.2
	Single	73	29.0
	Living with partner	29	11.5
	Domestic partnership	14	5.6
	Divorced	16	6.3
	Separated/Widowed	6	2.4
Race/ Ethnicity	White	204	81.9
	Hispanic	31	12.4
	Black	6	2.4
	Asian	8	3.2
Student Status	Yes	59	23.3
	No	194	76.7

Table 1. Participant characteristics (n = 254).
Note. Percentages are based on valid responses and may not total 100% because of rounding and missing data.

Reliability

The ESS demonstrated acceptable internal consistency (α = .80), with corrected item-total correlations ranging from .38 to .60. No item substantially altered overall reliability upon deletion, supporting retention of the full eight-item scale (Johns, 1991). The Sleep Disturbance Index likewise demonstrated acceptable consistency (α = .72), with corrected item-total correlations ranging from .31 to .53 (Buysse et al., 1989). The mean sleep disturbance score was 10.39 (SD = 5.35), indicating moderate overall disturbance and considerable variability across the sample.

Correlational Analyses

Pearson correlations supported the primary study hypotheses (Table 2). Overall sleep quality was significantly correlated with perceived sleep sufficiency (r = .65, p < .001), sleep latency (r = -.32, p < .001), nocturnal awakenings (r = -.24, p < .001), work-related sleepiness (r = -.43, p < .001), and sleep disturbance scores (r = -.37, p < .001). The direction of these correlations reflects the coding of the study variables. Similarly, reduced sleep

Variable	1	2	3	4	5	6	7	8
1. Overall Sleep Quality	—							
2. Sleep Sufficiency	.650***	—						
3. Sleep Latency	.324***	.333***	—					
4. Nighttime Awakenings	.240***	.270***	.138*	—				
5. Work-Related Sleepiness	.429***	.427***	.109	.201**	—			
6. Epworth Sleepiness Scale (ESS) Total	.129*	.157*	.238***	.087	.313***	—		
7. Sleep Disturbance Index	.371***	.347***	.245***	.313***	.303***	.336***	—	
8. Fatigue-Related Driving Accident/Near-Miss	.031	.036	.120	.049	.136*	.217***	.122	—

Table 2. Pearson correlations among primary study variables (n = 254).
*Note. Values are Pearson correlation coefficients. ESS = Epworth Sleepiness Scale. Sleep Disturbance Index was derived from selected Pittsburgh Sleep Quality Index (PSQI) items and is not the validated global PSQI score. Pairwise deletion was used for missing data. The negative correlation with fatigue-related driving incidents reflects the coding of the dichotomous driving incident variable. * p < .05. ** p < .01. *** p < .001.*

sufficiency was associated with greater work-related sleepiness (r = -.43, p < .001), more sleep disturbance (r = -.35, p < .001), and longer sleep latency (r = -.33, p < .001).

Higher ESS scores were significantly associated with greater work-related sleepiness (r = .31, p < .001), higher sleep disturbance scores (r = .34, p < .001), longer sleep latency (r = -.24, p < .001), and the fatigue-related driving incident variable (r = -.22, p < .001). The negative correlation reflects the coding of the dichotomous driving incident variable, in which respondents reporting a fatigue-related accident or near-miss were assigned the lower numerical value. Greater sleep disturbance was in turn associated with more frequent nocturnal awakenings (r = .31, p < .001), poorer sleep quality (r = -.37, p < .001), and greater work-related sleepiness (r = .30, p < .001).

Occupational scheduling variables also showed meaningful associations with fatigue outcomes. Longer shift lengths were associated with greater work-related sleepiness (r = .25, p < .001) and lower perceived sleep sufficiency (r = -.13, p = .034). Nontraditional work schedules were associated with higher ESS scores (r = -.15, p = .020). The two intent-to-leave items were strongly intercorrelated (r = .62, p < .001). Intent to leave one's current employer showed a small positive association with work-related sleepiness (r = .14, p = .030); intent to leave EMS showed a small association with nontraditional scheduling (r = -.13, p = .039). Associations between sleep variables and retention outcomes were generally modest in magnitude.

Differences by Certification Level

Independent-samples t-tests found no statistically significant differences between EMTs and paramedics in either Sleep Disturbance Index scores (EMTs: M = 8.99, SD = 5.33; paramedics: M = 8.31, SD = 4.04; t[244] = 1.10, p = .274, d = 0.14) or ESS total scores (EMTs: M = 8.09, SD = 4.31; paramedics: M = 7.65, SD = 4.24; t[247] = 0.80, p = .422, d = 0.10). Sleep-related difficulties seemed to be present at similar levels across certification levels within the present sample.

Sleep Medication Use

Exploratory analyses compared sleep disturbance and daytime sleepiness between providers reporting and not reporting sleep medication use. Providers using sleep medications showed modestly higher sleep disturbance scores (M = 9.59, SD = 4.45) than

non-users (M = 8.39, SD = 4.87), though this difference did not reach statistical significance (t[238] = 1.71, p = .090, d = 0.25). No significant group difference in ESS scores was observed (t[241] = -1.09, p = .275). These findings suggest a trend toward greater sleep difficulty among medication users that requires further investigation but should be interpreted cautiously given the small effect size and nonsignificant p-value.

Fatigue-Related Driving Safety

Providers who reported having experienced a fatigue-related motor vehicle accident or near-miss incident demonstrated significantly higher ESS scores than those without such history (M = 9.33, SD = 4.38 vs. M = 7.28, SD = 4.10), t(240) = 3.45, p = .001, d = 0.49. This moderate effect size indicates meaningfully greater daytime sleepiness among providers reporting fatigue-related driving events, supporting H3. Providers with fatigue-related driving history also demonstrated higher sleep disturbance scores (M = 9.70, SD = 4.44) relative to those without such history (M = 8.41, SD = 4.87), although this comparison approached but did not reach statistical significance, t(238) = 1.90, p = .059, d = 0.27. Given the observed differences in daytime sleepiness between groups, additional analyses were conducted to examine whether sleep- and scheduling-related variables independently predicted fatigue-related driving outcomes when considered simultaneously.

To further examine factors associated with fatigue-related driving incidents, a binary logistic regression was conducted using fatigue-related motor vehicle accidents or near-miss incidents as the dependent variable. Predictor variables included ESS total score, sleep disturbance, work-related sleepiness, secondary EMS employment, shift length, work schedule, overall sleep amount, nontraditional scheduling, and sleep medication use.

The overall logistic regression model (Table 3) was statistically significant, x^2 (9) = 24.38, p = .004, indicating that the set of sleep- and scheduling-related variables reliably distinguished between providers who did and did not report fatigue-related driving incidents. The model explained approximately 14.2% of the variance in fatigue-related driving outcomes based on the Nagelkerke R^2 value, with an overall classification accuracy of 73.4%.

Predictor	Wald x^2	p	Interpretation
Epworth Sleepiness Scale (ESS) Total	7.27	.007	Significant positive predictor
Work Schedule	4.52	.033	Significant predictor
Sleep Disturbance Index	—	> .05	Not significant
Work-Related Sleepiness	—	> .05	Not significant
Secondary EMS Employment	—	> .05	Not significant
Shift Length	—	> .05	Not significant
Sleep Sufficiency	—	> .05	Not significant
Nontraditional Schedule	—	> .05	Not significant
Sleep Medication Use	—	> .05	Not significant

Table 3. Binary logistic regression predicting fatigue-related driving accidents or near-miss incidents (n = 254).

Note. ESS = Epworth Sleepiness Scale. Predictor variables included ESS total score, Sleep Disturbance Index, work-related sleepiness, secondary EMS employment, shift length, work schedule, perceived sleep sufficiency, nontraditional scheduling, and sleep medication use. Only ESS total score and work schedule emerged as statistically significant independent predictors.

ESS total score emerged as a significant independent predictor of fatigue-related driving incidents, Wald = 7.27, p = .007. Higher ESS scores were associated with greater likelihood of reporting a fatigue-related

Statistic	Value
Model x^2 (9)	24.38
p	.004
Nagelkerke R^2	.142
Overall Classification Accuracy	73.4%

Table 4. Model summary.

accident or near-miss event. Work schedule characteristics also independently predicted fatigue-related driving outcomes, Wald = 4.52, $p = .033$, suggesting that scheduling structure may contribute to operational driving risk even after accounting for sleep-related variables.

Other variables, including sleep disturbance, work-related sleepiness, secondary EMS employment, shift length, overall sleep amount, nontraditional scheduling, and sleep medication use, did not independently predict fatigue-related driving incidents within the full model. Although several sleep-related variables demonstrated bivariate relationships with fatigue-related driving history, ESS total score remained the strongest independent predictor within the multivariable model. This pattern shows that functional daytime impairment may represent a more direct operational risk factor than general sleep quality measures alone.

These findings suggest that daytime functional sleepiness and operational scheduling characteristics may represent more direct correlates of fatigue-related driving risk among EMS providers than general sleep quality measures alone.

Regression Analyses: Intent to Leave Current Employer

A multiple linear regression (Table 5) examined whether ESS scores, Sleep Disturbance Index, perceived sleep sufficiency, work-related sleepiness, shift length, and nontraditional scheduling predicted intent to leave one's current EMS employer. The overall model was not statistically significant ($F[6, 233] = 1.09$, $p = .372$, $R^2 = .027$, adjusted $R^2 = .002$), accounting for approximately 2.7% of variance in the outcome. Work-related sleepiness approached significance as an independent predictor ($B = .430$, $\beta = .15$, $p = .052$), suggesting a trend toward greater turnover intent among providers experiencing greater on-shift fatigue. Remaining predictors such as ESS scores ($\beta = -.06$, $p = .410$), sleep disturbance ($\beta = .05$, $p = .512$), sleep sufficiency ($\beta = .003$, $p = .969$), shift length ($\beta = .007$, $p = .915$), and nontraditional scheduling ($\beta = .031$, $p = .641$), did not independently predict turnover intent. Collinearity diagnostics were satisfactory, with VIF values ranging from 1.03 to 1.41.

Predictor	Intent to Leave Employer β	*p*	Intent to Leave EMS β	*p*
Epworth Sleepiness Scale (ESS) Total	.06	.410	.04	.624
Sleep Disturbance Index	.05	.512	.01	.858
Sleep Sufficiency	.003	.969	.02	.832
Work-Related Sleepiness	.15	.052	.15	.059
Shift Length	.007	.915	.14	.033*
Nontraditional Schedule	.031	.641	.01	.851

Table 5. Multiple linear regression models predicting intent to leave current employer and intent to leave EMS ($n = 254$).
Note. β = standardized regression coefficient. VIF values ranged from 1.03 to 1.41, indicating no evidence of problematic multicollinearity. Neither overall regression model reached statistical significance. Consequently, individual regression coefficients, including the significant shift-length coefficient in the intent-to-leave-EMS model, should be interpreted cautiously. $p < .05$.

Regression Analyses: Intent to Leave EMS

A parallel regression (Table 5) examined predictors of intent to leave EMS entirely. The overall model was again nonsig-

Statistic	Intent to Leave Employer	Intent to Leave EMS
F	1.09	1.21
Degrees of Freedom	(6, 233)	(6, 233)
p	.372	.300
R^2	.027	.030
Adjusted R^2	.002	.005
Nontraditional Schedule	.031	.01

Table 6. Model summary.

nificant (F[6, 233] = 1.21, p = .300, R^2 = .030, adjusted R^2 = .005). Although shift length emerged as a statistically significant individual predictor (β = .14, p = .033), providers working longer shifts reported lower intent to leave EMS, the overall regression model was not statistically significant. Therefore, this finding should be interpreted cautiously. Work-related sleepiness again approached significance (B = .364, β = .15, p = .059), with greater on-shift sleepiness trending toward higher turnover intent. ESS scores (β = -.04, p = .624), sleep disturbance (β = .01, p = .858), sleep sufficiency (β = .02, p = .832), and non-traditional scheduling (β = .01, p = .851) did not independently predict this outcome. VIF values remained acceptable, ranging from 1.03 to 1.41.

DISCUSSION

The study findings point to a pattern in which fatigue and poor sleep are not minor issues in EMS, but everyday realities for many providers that have real effects on operational safety and, to a lesser degree, decisions about staying in the profession. Nearly two-thirds of respondents characterized their sleep as poor or fairly poor, nearly three-fifths reported insufficient sleep, and almost half reported significant sleepiness at work. These proportions are consistent with prevalence data reported across prior EMS studies and are not marginal or confined to a fatigued subgroup: they describe the average experience of EMS providers in this sample (O'Brien et al., 2025; Patterson et al., 2010; Patterson et al., 2012a).

The normalization of fatigue within prehospital care culture runs deep (Patterson et al., 2018a). Working a 24-hour tour after a day shift, holding two or three EMS jobs simultaneously, sleeping in fitful 90-minute increments between overnight calls are not experiences unique to individual providers, but structural features of how many EMS systems are staffed and operated (Rivard et al., 2020). The current findings show that higher levels of daytime sleepiness were associated with greater reports of fatigue-related driving incidents, providing measurable evidence of the real-world impact of poor sleep in EMS. That relationship is the clearest and most practically significant finding to emerge from the data. Providers who reported fatigue-related motor vehicle accidents or near-miss events had meaningfully higher ESS scores than those who did not, with an effect size in the moderate range. Emergency vehicle operation already carries inherent risk: intersection crossings against traffic signals, high-speed response through urban environments, and navigation under stress, and this suggests that a substantial subset of providers may be performing these tasks while also being significantly fatigued. The finding that nearly 30% of respondents had experienced a fatigue-related accident or near-miss at some point in their careers is consistent with documented risks among other overnight and shift-working transportation populations (Lee et al., 2016) and underscores the operational scope of the problem. The multivariable analyses further strengthened this finding. ESS scores remained a significant independent predictor of fatigue-related driving incidents even after accounting for scheduling characteristics, shift length, sleep disturbance, work-related sleepiness, and sleep medication use. In contrast, broader sleep quality measures did not independently predict driving outcomes within the full model. This pattern may indicate that daytime functional impairment, rather than sleep quality alone, may represent the more immediate operational risk factor within EMS settings (Dinges, 1995). From a practical standpoint, this distinction matters. Providers may normalize poor sleep quality while underrecognizing the degree to which excessive day-

time sleepiness affects attention, vigilance, and reaction time during emergency vehicle operation (Van Dongen et al., 2003).

The relationship between nontraditional scheduling, shift length, and sleep outcomes also merits attention. Providers working overnight or rotating schedules reported higher ESS scores, consistent with the well-established circadian mechanisms through which nocturnal work impairs sleep quality and daytime alertness (Barth et al., 2022; Boivin & Boudreau, 2014). Longer shifts were associated with greater work-related sleepiness and lower perceived sleep sufficiency, which is perhaps an intuitive finding, though one that carries practical implications for systems considering whether 12- or 24-hour tour structures adequately support provider functioning across the duration of the shift (Patterson et al., 2018b; Weaver et al., 2015). These findings generally supported the hypothesis that nontraditional scheduling structures and extended shifts would be associated with poorer sleep-related outcomes among EMS providers.

Contrary to what might be expected, providers working longer shifts reported lower intent to leave EMS rather than a higher intent. This finding likely reflects occupational and attitudinal selection rather than a protective effect of long hours. Providers who choose or remain in 24-hour tour positions may be those who are more deeply embedded in EMS culture, more financially reliant on consolidated shift structures that permit secondary employment (Rivard et al., 2020), or simply more adapted to the demands of extended operational tours. Regardless of the mechanism, the finding cautions against interpreting shift length as a straightforward marker of dissatisfaction. However, because the shift-length coefficient emerged within an overall nonsignificant regression model, this finding should be interpreted cautiously and requires replication.

More broadly, the regression results demonstrate that sleep disruption as measured here is not a strong independent predictor of turnover intent. This is consistent with the hypothesis (H5) that anticipated a modest rather than robust relationship, and it reflects the genuinely multidetermined nature of retention decisions within EMS (Cash et al., 2024; Crowe et al., 2018; Powell et al., 2025). A provider who is fatigued, underpaid, managing organizational dysfunction, and working without adequate support is more likely to leave than one for whom only one of those conditions applies. Sleep disruption does not operate in isolation; it amplifies existing occupational strain without being its primary driver (Patterson et al., 2015).

Nevertheless, the repeated near-significance of work-related sleepiness as a predictor of turnover intent across both regression models suggests that on-shift fatigue may carry some incremental association with retention outcomes that a larger and more statistically powered study might detect more reliably. The present analyses should not be interpreted as ruling out a meaningful sleep-retention link, only as failing to confirm it within this sample and model specification.

EMS has historically rewarded endurance over recovery and treated exhaustion as a credential rather than a risk factor (Patterson et al., 2018a). Providers who raise concerns about fatigue may encounter institutional resistance, implicit peer pressure toward stoicism, or structural barriers such as staffing shortages, mandatory overtime, or financial necessity, that make adequate sleep genuinely difficult to prioritize even when motivation exists. Interventions that do not account for this cultural context are unlikely

to produce lasting change (Barger et al., 2018). Effective fatigue management in EMS will require not only educational programs or scheduling modifications, but a meaningful shift in how operational leadership conceptualizes and responds to provider sleep health as a safety-critical variable (Patterson et al., 2018a).

Limitations

The study relied exclusively on self-reported data, introducing potential for recall and social desirability bias. Given the normalization of fatigue within EMS culture, some providers may have underestimated their own impairment or reported functioning more adequate than objective assessment would confirm (Van Dongen et al., 2003). The cross-sectional design precludes causal inference; observed associations between sleep disruption and occupational outcomes may reflect shared variance with broader organizational stressors rather than independent effects of sleep per se.

The convenience sample introduces selection concerns. Providers experiencing greater fatigue or dissatisfaction may have been more motivated to participate, potentially inflating prevalence estimates relative to the broader EMS workforce (Rivard et al., 2021). The sample's demographic composition, which was predominantly White, urban, and employed across hospital-based and private services, may not generalize to rural, volunteer, or fire-integrated EMS systems with distinct staffing structures and operational demands (Rivard et al., 2021).

The absence of objective sleep measurement is an additional limitation. Actigraphy, polysomnography, and psychomotor vigilance testing would provide physiologic data not subject to the subjective reporting biases inherent in self-report instruments (Patterson et al., 2014). Similarly, objective operational performance data, such as documented vehicle incidents, clinical error rates, or formal safety reports, were not available and would substantially strengthen the safety-related findings. Secondary employment patterns, caffeine use, commute burden, and family care responsibilities also were not comprehensively examined, despite their likely relevance to sleep and fatigue outcomes (Rivard et al., 2020).

Because numerous statistical analyses were conducted, the possibility of Type I error cannot be excluded. Consequently, statistically significant findings should be interpreted cautiously until replicated in future studies.

Future Directions

Future studies should include longitudinal designs focused on understanding how fatigue accumulates across EMS careers and whether chronic sleep disruption predicts clinically meaningful health or occupational outcomes over time. The cross-sectional literature has established that fatigue is prevalent; what remains less understood is its trajectory and long-term consequences for provider health and functioning (O'Brien et al., 2025; Patterson et al., 2012a).

Future studies incorporating objective sleep and performance measurement would substantially advance the field. Wearable sleep tracking, validated cognitive performance batteries, and reaction time assessments could provide a more accurate characterization of the gap between how fatigued providers perceive themselves to be and how they are

actually performing, a gap that existing research indicates may be considerable (Lowe et al., 2017; Van Dongen et al., 2003). Real-time fatigue monitoring interventions have demonstrated initial promise in air-medical settings and represent a productive model for further development in ground EMS contexts (Patterson et al., 2019).

The relationship between fatigue and emergency vehicle operation deserves dedicated investigation. Despite the frequency with which EMS personnel operate vehicles while fatigued and the documented consequences of drowsy driving in other transportation contexts (Dinges, 1995; Lee et al., 2016), the EMS-specific literature on this topic remains sparse. Studies examining reaction time, lane deviation, hazard detection, and near-miss incident rates among fatigued EMS crews would provide valuable data for both policy development and operational safety planning.

Studies evaluating protected rest periods during extended tours, alternative shift configurations, mandatory recovery minimums between consecutive work periods, and formal fatigue monitoring programs could identify which approaches produce meaningful reductions in impairment without exacerbating existing staffing shortages (Martin-Gill et al., 2018; Patterson et al., 2018b; Thielmann & Böckelmann, 2024). Qualitative and mixed-methods research examining provider and supervisory attitudes toward fatigue management would further inform how interventions can be designed to be both realistic within EMS operations and culturally acceptable within EMS environments (Barger et al., 2018).

As EMS systems continue to face recruitment and retention challenges of considerable scope, understanding the mechanisms through which occupational strain translates to provider exit will become increasingly important for the development of effective and sustainable workforce solutions (Cash et al., 2024; Powell et al., 2025).

CONCLUSION

Fatigue is not an incidental feature of EMS work; it is a structural consequence of how the profession is organized and staffed (Patterson et al., 2012a; Patterson et al., 2018a). This study found that poor sleep quality, excessive daytime sleepiness, and work-related fatigue were the norm rather than the exception among the EMS providers surveyed, and that elevated daytime sleepiness was meaningfully associated with fatigue-related driving accidents and near-miss incidents. Scheduling characteristics, particularly overnight and rotating work, contributed to greater sleep disruption and daytime impairment (Barth et al., 2022; Boivin & Boudreau, 2014). Sleep variables showed limited independent predictive value for turnover intent, though work-related sleepiness and shift length demonstrated associations with retention outcomes that merit continued investigation.

The implications of these findings extend beyond individual provider wellness. Emergency medical services exist to deliver safe, effective prehospital care, and the cognitive and operational demands of that work are poorly served by a workforce operating under chronic sleep restriction (Alhola & Polo-Kantola, 2007; Lowe et al., 2017). Addressing fatigue in EMS will require recognition at the organizational and systems level that sleep health is not a personal responsibility to be managed off-duty, but an operational variable that agencies, researchers, and policymakers have a shared stake in protecting (Patterson et al., 2017; Patterson et al., 2018a).

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RESEARCH REPORTS

FACILITATED VIDEO CASE-BASED LEARNING: AN EXPLORATORY SINGLE-CASE STUDY OF PARAMEDIC WORKPLACE LEARNING

Adiel Garcia, EdD, NRP*[1,2]

Author Affiliations: 1. Johnson County EMS (MED-ACT), Olathe, KS, USA; 2. Creighton University, Omaha, NE, USA.

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**Corresponding Author:* adiel.medic@gmail.com

ABSTRACT

The purpose of this exploratory single-case study was to explore whether facilitated video case-based learning might provide an alternative teaching and learning solution to high-fidelity patient simulation for paramedic workplace learning. The study was informed by the New Kirkpatrick Model® for training evaluation and Bloom's revised taxonomy for the identification of higher-order thinking skills. Five paramedics who work in a city fire department within a high-performance EMS system in the midwestern United States participated in the study. The participants engaged in a facilitated video case-based learning intervention that presented a novel case of a medical emergency. Through observation of participant behavior and thematic analysis of post-intervention interviews, the study examined the influence of this learning approach on the development of higher-order thinking skills. Findings revealed that facilitated video case-based learning was perceived as highly engaging and relevant and contributed meaningfully to knowledge acquisition and the development of higher-order thinking skills. The results influence our understanding of paramedic learning and can address policy and practice issues that make ongoing paramedic education more accessible, especially in resource-poor areas globally.

INTRODUCTION

In emergency medical services (EMS) education, clinical simulation has positioned itself as a principal tool of experiential learning, with 89% of paramedic programs in the United States utilizing it for teaching and learning (Diamond & Bilton, 2021; Herrera-Aliaga & Estrada, 2022). Although clinical simulation is an effective instructional intervention, its resource intensiveness, space constraints, and economic investment present substantial challenges (Au et al., 2023).

Facilitated video case-based learning (FVCBL) is the presentation of clinical cases via video, which have embedded discussion pauses, and are facilitated by a subject matter specialist. There is little to no evidence in the literature about the use of this approach in EMS education. This study examines that gap,

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reporting on the research to examine the potential of FVCBL for the development of higher-order thinking skills in EMS education.

This study examined the following research questions:

1. What are the experiences of paramedics participating in facilitated video case-based learning?
2. How do paramedics demonstrate higher-order thinking skills in facilitated video case-based learning?

The results suggest that facilitated video case-based learning may offer a viable, more accessible educational strategy for paramedic learning. The findings indicate that FVCBL was perceived as highly engaging and contextually relevant and supported knowledge acquisition and higher-order cognitive development.

LITERATURE REVIEW

Clinical Simulation

The creation of scenarios or settings that enable simulated healthcare experiences for the purpose of practicing, learning, evaluating, testing, and/or researching, is defined as clinical or healthcare simulation (Lioce, 2020). One of its primary benefits is that clinical simulation provides a safe environment for practice prior to engaging in real-life application. Clinical simulation has also been shown to increase competence and minimize time for clinicians when conducting patient assessment, medication administration, and medical procedures, ultimately resulting in lower levels of stress for patients (Mawyin-Muñoz et al., 2025; Turan & Pekmezci, 2026).

Evidence supporting the educational value of clinical simulation spans multiple areas of healthcare education. A meta-analysis by Okuda et al. (2009) reviewed clinical simulation's utility in different areas of medical education and demonstrated clinical improvement in laparoscopic surgery and advanced cardiac life support protocols during cardiac arrest. Additionally, clinical simulation indicated valuable educational benefits across basic science, physical examination, anesthesiology, surgery, obstetrics, pediatrics, critical care, and emergency medicine. Despite these benefits, clinical simulation was found to require more faculty, preparation time, up-front and maintenance costs, and space than traditional teaching methods. Clinical simulation's effectiveness also depended on the simulator's capacity to emulate human physiology/pathophysiology, the infrastructure, and the educators' expertise. These requirements may present significant challenges for educational programs, even when advanced simulation resources are available but cannot be effectively implemented. McKenna et al. (2015) established that even when advanced, fully programmable manikins are available to some educational programs, those expensive resources are not used consistently, or at all, mostly because of lack of faculty training. Furthermore, Okuda et al. (2009) argued that debriefing processes were imperative to simulation; without them, non-technical skills showed no improvement.

More recent research has continued to demonstrate both the potential and limitations of simulation-based education. Daneshfar and Moonaghi (2025) reported notable enhancements in the clinical decision-making, judgment, and self-confidence of nursing students using high-fidelity simulation. However, they cautioned that without ongoing reinforcement, these skills may diminish over time. Some noteworthy challenges includ-

ed variability in debriefing processes, lack of continuous practice, and inadequate faculty training.

In addition to these implementation challenges, the potential for unintended effects of high-fidelity simulation warrants consideration. Concerningly, Massoth et al. (2019) found that high-fidelity simulation participants exhibited overconfidence, regardless of similar or lower test scores than the low-fidelity group, which may lead to increased risk-taking and medical errors in the field. Finally, Meyers et al. (2020) suggested future research on video-based learning, citing high human and technological needs for high-fidelity simulation.

Video-Based Learning

Video-based learning (VBL) refers to the acquisition of knowledge and/or skills through watching videos as the primary source of information, supplemented by audio, images, and text (Sabli et al., 2021). VBL demonstrates pedagogical benefits, including consistency of instruction, flexibility, scalability, and the ability to visually demonstrate complex or otherwise inaccessible processes (Curtis et al., 2018). Studies show that videos enhance recall, understanding, and engagement, connect new content to prior knowledge, and are most effective when videos are short, purposeful, and embedded with guided discussions and active learning tasks (Mitra et al., 2010). When effectively designed, video-based learning can increase interactivity, collaboration, and engagement (Sherer & Shea, 2011).

In medical education, VBL has demonstrated comparable or superior performance to traditional instruction for practical skills, including disaster medicine procedures, simulation debriefing, and CPR training (Curtis et al., 2018; Grant et al., 2010; Lynch et al., 2005). However, marked limitations persist, including depersonalization, lack of real-time support, technology dependence, excessive video length, and reduced learner interaction when videos are poorly designed (Iskru & Schulz, 2020; Sabli et al., 2021).

Case-Based Learning

Case-based learning (CBL) stimulates knowledge and skills acquisition through contextualized, authentic cases that promote inquiry, collaboration, and application of prerequisite knowledge (Perez et al., 2022; Williams, 2005). Effective cases are realistic, concise, thought-provoking, contain conflict, lack clear-cut answers, demand decision-making, and promote empathy and reflection (Davis, 1993).

In medical education, CBL is associated with greater student engagement, enjoyment, and perceived learning compared to lectures, particularly in fostering clinical reasoning, diagnostic interpretation, logical thinking, and teamwork (Kassebaum et al., 1991; Williams, 2005). Learners value challenging cases and benefit from expert facilitation, preparatory work, and timely feedback (Perez et al., 2022). Multiple comparative studies demonstrate improved satisfaction, deeper learning, and enhanced critical thinking with CBL (George et al., 2020; Parmar, 2018). Recent evidence supports the effectiveness of independent, blended, and online CBL formats, with reported improvements in knowledge scores, interest, and satisfaction when supplemented with faculty feedback (Clancy et al., 2024; Donkin et al., 2023).

In emergency medical systems, CBL is used for education, reflection, and quality improvement through structured review of real cases. This approach supports reflective practice, shared learning, and system-level improvements in educational and operational policies (Carenzo et al., 2022).

Higher-Order Thinking Skills

Bloom's revised taxonomy reframed cognition as an active process and distinguished between the knowledge dimension (factual, conceptual, procedural, and metacognitive) and the cognitive process dimension (remembering, understanding, applying, analyzing, evaluating, creating) (Krathwohl, 2002). Higher-order thinking skills (HOTS) require the reorganization of knowledge through understanding, breaking apart, integrating, judging information, and creating original solutions to complex problems (Chaojing, 2023; Muhibbuddin et al., 2023). Creativity is positioned as the pinnacle of HOTS, emphasizing the production of original patterns or solutions, while highlighting that all knowledge types can intersect with all cognitive processes.

Effective strategies for enhancing HOTS include complex open-ended questioning, inquiry formulation, collaborative discussion, and guided metacognitive reflection (Chaojing, 2023). Critical thinking is central to HOTS (Zhong & Song, 2024), and can be cultivated through explicit instruction, authentic learning environments, reflective self-assessment, and sustained practice, enabling how to think rather than what to think (Nippold, 2024).

Empirical evidence in medical education demonstrates that critical thinking is positively correlated with professional competence, caregiving quality, reduced medical errors, and improved patient outcomes (Chang et al., 2011; Karaca et al., 2023). These findings underscore the imperative for paramedics to develop HOTS through comprehensive education that integrates scientific evidence, technology, and innovation.

CONCEPTUAL FRAMING

Constructivism

Facilitated video case-based learning employs many concepts and features of constructivism, which encourages experimentation, participation, and action through active learning. The tenets of constructivism assert that knowledge is constructed; occurs through interactions and experiences with the environment; is dynamic and changing; and is rooted in biological, social, and cultural interactions (Doolittle & Hicks, 2003). Through inquiry, exploration, dialogue, and reconciliation with prior knowledge, constructivism posits that formulation of meaning and understanding develops through experiences and reflection (Harasim, 2017).

The Kirkpatrick Model

Kirkpatrick's four-level model–reaction, learning, behavior, and results–is a widely used framework for evaluating training effectiveness (Kirkpatrick, 1979; Morra et al., 2024). The New Kirkpatrick Model® incorporates relevance, engagement, confidence, commitment, critical behaviors, required drivers, and on-the-job learning to the original model, while elucidating that results need to be defined globally in the context of profitability or mission accomplishment (Kirkpatrick & Kirkpatrick, 2022). Kirkpatrick and Kirkpatrick (2016) clarify that the levels do not have to be evaluated sequentially, nor are they causal

or of equal importance, but evidentiary, and therefore, not every program "requires a full evaluation package" (p. 22).

METHODS

Given the uniqueness of the learning intervention and the lack of existing research in this specific area, an exploratory single-case study design was appropriate for this study. Facilitated video case-based learning was designed to contain similar instructional features that have led to learning in clinical simulation (e.g., realism, scenario validation, debriefing, expert guidance). Prior to the study being conducted, an ethics review was submitted and approved by the Institutional Review Board (IRB) of Sam Houston State University (IRB-2025-117).

Participants

A cohort of five fire-medics, who work in a fire department as part of a high-performance EMS system, was utilized in the study. The EMS system is comprised of one county ambulance third-service, eight city or consolidated fire departments or districts, the Office of the Medical Director, and the Emergency Communications Center. The study's researcher is an employee of the county ambulance service.

An internal email was sent by the fire department's EMS chief, informing their employees of the opportunity to participate in this study and directing them to an external Qualtrics link which contained detailed information about the study and the consent forms. The inclusion criteria required certified paramedics who:

1. Were licensed and employed full-time by the fire department;
2. Were credentialed at the paramedic level;
3. Had a minimum of one year of professional experience within the EMS System;
4. Had a maximum of 25 years of professional, paramedic work experience;
5. Were willing to participate in a face-to-face FVCBL scenario (learning intervention); and
6. Were willing to participate in a one-on-one interview after the learning intervention.

Video Selection

The video utilized for the FVCBL scenario was from Untold Stories of the ER (Harmon & Massar, 2015), available on YouTube (FilmRise, 2015). The case selected is titled Continuing Ed and features a patient in cardiac arrest (with several instances of return of spontaneous circulation [ROSC] and re-arrest) that is transported to the hospital by paramedics, with a final diagnosis of Brugada syndrome. Video timing, sequence markers, pauses, activities, and questions were identified and compiled into a facilitation guidebook. Learning objects (e.g., electrocardiograms, laboratory results, infographics) were developed and introduced throughout the scenario. Since the video did not have a pedagogical design, creation of the learning objects was indispensable to support teaching and learning. The content validity of the clinical case, learning objects, and facilitation guidebook were corroborated through separate expert consultations with two emergency medicine physicians who served as medical directors for that EMS system.

Learning Intervention

The participants sat as a group, side-by-side, and in one row while viewing the video. Each participant was provided with a blank sheet of paper to take notes, and a protocol book and field reference manual were placed on the table for their reference. The protocol book delineates treatment guidelines in the EMS system as authorized by the Office of the Medical Director. The field reference guide is a supplement to the protocol book and contains mostly drug dosages, checklists, and clinical assessment scales.

When volunteering through the Qualtrics link, each participant selected a pseudonym (Akakael, Jax, Justin Case, OFD 187, Tar O'Reilly) for themselves, which was used during the learning intervention and interview. The FVCBL experience was recorded with a smart phone and that recording, along with the participants' handwritten notes, informed the observation field notes. Although the video length was less than 15 minutes, the learning intervention lasted 85 minutes due to strategic discussion pauses. During the pauses, the facilitator inquired, guided, introduced learning objects, and even partnered with the participants, making the learning more interactive and collaborative. Wrong answers were not immediately corrected but were recognized by the facilitator who elicited perspectives from the other participants, introduced supplemental information, and/or engaged in open-ended inquiry.

Data Collection

An observation protocol captured contextual factors, participant behaviors, engagement, and attitudes, and included pre-determined categories from the New Kirkpatrick Model® (reaction and learning) and Bloom's revised taxonomy HOTS levels (analyzing, evaluating, and creating). One-on-one participant interviews, via videoconference, took place within 14 days of the learning intervention and consisted of semi-structured, open-ended questions.

Data Analysis

Descriptive and reflexive observation notes were taken from the FVCBL recording, documenting the participants' body language, verbal/nonverbal expressions, interactions, discussions, and actions. The interviews underwent inductive and deductive analysis, with prior member checking. The initial coding cycle utilized in vivo coding and the second cycle consisted of axial coding. A predetermined codebook was created for the deductive analysis and included a priori categories taken from the New Kirkpatrick Model® and Bloom's Revised Taxonomy. To increase trustworthiness, an external coder (Doctor of Education and professor of paramedicine, with complete and current Collaborative Institutional Training Initiative trainings) conducted a separate analysis of the interview transcripts.

FINDINGS

Observations

Non-verbal expressions demonstrated emotional, social, and cognitive reactions to the subject matter, video elements, and learning environment. Examples include leaning forward toward the television, frowning, smiling and laughing, raising eyebrows, audible paralinguistics, and a myriad of head-nodding, -shaking, and -tilting.

Participant communications largely centered on clinical discussions about patient assessment and treatment, medical protocols, and best practices. Peer teaching and collaborative learning to discuss differential diagnoses, stratify prognosis, reinforce protocols, validate clinical impressions, and analyze case details were witnessed throughout the intervention.

Participant actions and interactions involved each other, the facilitator, and the learning objects. There were debates about the doctor's orders, leading to cross-checking medication dosages and clinical interventions. Participants were observed consulting the protocol book (and app), field guide, and Internet to cross-reference information. Additionally, the participants reanalyzed the ECGs and laboratory results at different points throughout the scenario, as differential diagnoses were ruled out or reinforced.

Examples of the aforementioned include an early discussion where Tar O'Reilly highlighted that the paramedics in the video were in the back of a moving ambulance which presented a safety issue that needed to be considered when determining the most immediate actions to best manage the cardiac arrest. Also, the participants differentiated between the priorities of a medical versus a traumatic cardiac arrest, making a real-world connection between the video content and their protocols/procedures, which was an imperative factor in determining whether the ambulance would need to pull over or proceed to the hospital if the cardiac arrest had occurred en route.

Later, when discussing reversible cardiac arrest causes, Tar O'Reilly shared that the patient's medical history is key in ruling in/out hyperkalemia in the field. Also, Justin Case, Tar O'Reilly, Jax, and Akakael discussed the value, or lack thereof, of the laboratory exams which the doctor ordered once the patient had arrived at the hospital, influencing one another's perspectives of how the results of a complete blood count (CBC) versus a comprehensive metabolic panel (CMP) might change their treatment. Subsequently, as the video played, Jax was observed examining the printed laboratory results in response to the doctor mentioning that the lab values were normal. Then, OFD 187 turned to Akakael and stated, "Torsades," interpreting the changed ECG rhythm on the screen, while Jax assented with a nod. As the case progressed, the participants collectively analyzed the repeat ECG, sharing their findings out loud, with Akakael identifying ST elevations in multiple leads and OFD 187 noting the presence of reciprocal changes. And after the final diagnosis of Brugada syndrome was revealed, the participants were witnessed explaining concepts to each other, with Jax pointing out to OFD 187 some features on the ECG printout. Tar O'Reilly then asked Jax how he knew the patient had Brugada syndrome and Jax responded in part, "…Brugada looks like a slide, it's called 'coved,' it looks like a slide on a playground."

Finally, at the end of the learning intervention, all participants were observed using their phone to scan a printed QR code on a table at the back of the classroom, which they were told would give them access to all the studies that were referenced during the learning intervention.

Participant Interviews

The inductive analysis led to three themes: participant reactions, perceptions of learning, and demonstration of higher-order thinking skills.

Theme 1: Participant Reactions

Participant reactions assess the perceptions of, and attitude toward, the training. This theme considers the participants' immediate responses to FVCBL, capturing their approval, perceived relevance, and engagement during the training experience. Participant reactions includes three sub-themes: favorability, engagement, and relevance.

Favorability deals with the satisfaction of having participated in the learning intervention. Engagement deals with the participants' attentiveness, active participation, and contributions to the discussions. And relevance deals with the participants' feelings that the scenario represented a real-life event and/or depicted the complexities of their work.

Key phrases that emerged were: "it was enjoyable and I did learn some interesting things" (Akakael), "was representative of the cases we run in the field…had a positive experience for sure" (Justin Case), "I was locked in…I was pretty engaged" (Jax), and "was surprised by the effectiveness and how well it was engaging me…it provides a safe area to learn immersed" (OFD 187).

Although some participants expressed a preference for hands-on learning and initial skepticism regarding the clinical validity of the dramatic video content, with Akakael (who was the most critical of the learning intervention) stating, "it's hard to take those [television videos] seriously because most of the time they're so ridiculous," the findings signal that they nevertheless viewed the learning intervention positively.

Theme 2: Perceptions of Learning

Perceptions of learning assess the participants' knowledge acquisition from the learning intervention. This theme accounted for the attainment of intended knowledge, skills, and abilities during the learning scenario. Perceptions of learning includes three sub-themes: attitude, confidence, and commitment.

Attitude deals with whether the participants thought the training was worthwhile and would be beneficial to patient care. Confidence deals with the participants' feelings that they are or can be prepared to apply the learnings in real life. And commitment deals with the participants' intent to use what was learned.

Key phrases that emerged were: "appreciated this type of learning style" (Tar O'Reilly), "easier for me to learn" (Justin Case), "our interactive discussions provided confidence in what I am doing and lessons on what we should be doing" (Akakael), and "it was presented in a way that I'll never forget" (OFD 187).

Participants perceived the learning as extending beyond the immediate session and described how the concepts would remain part of their future clinical reasoning. After participating in the learning intervention, Justin Case shared that he had responded to real syncope/near-syncope patients and had performed 12-lead ECGs on them, reflecting, "I had that class in the back of my mind, but didn't see any of the indicators for that [Brugada syndrome], but it was part of my thought process with those patients." This enduring vigilance was reinforced by a shift in how participants interpreted normal findings, exemplified by Tar O'Reilly's conclusion that his "biggest takeaway was just saying, 'I'm not gonna use the term normal anymore,'" emphasizing that a normal looking ECG does not rule out cardiac pathology and should instead be referred to and documented as

"non-diagnostic." Similarly, Akakael reflected that after perhaps forgetting the name of the actual syndrome he had learned, he would "at least be able to voice concern or know that something is abnormal, as opposed to just thinking that it's perfectly fine." Together, these reflections support the assertion that participants anticipated long-term retention, maintaining diagnostic caution, and a heightened index of clinical suspicion.

Theme 3: Demonstration of Higher-Order Thinking Skills

Demonstration of higher-order thinking skills (HOTS) includes evidence of information reorganization and/or the creation of original methods or actions to resolve the intricate clinical issue. This theme encompasses cognitive processes that require learners to engage in complex reasoning, problem-solving, and the application of knowledge in novel situations. Demonstration of HOTS includes three sub-themes: analyzing, evaluating, and creating.

Analyzing refers to the participants dissecting information, identifying relationships and patterns, and/or making connections among ideas. Evaluating refers to the participants making criteria-based judgments and assessing the information's value to justify decisions. And creating refers to the participants combining different elements to produce new ideas, outputs, and/or plans.

Key phrases that emerged were: "your questions led us down the road of opening up the case and I think that was very beneficial" (Akakael); "the way it was paused and then I had to [think]: 'What would I do here'? 'What did I see'? 'What could be going on'? 'What would I do differently'?...I think that's what really made the difference" (OFD 187); "I was kind of going down the same routes that the doctor [in the video] was going down" (Jax); "the case was taking place in an ER and they have more tools available to them…so we [prehospital] have to stop and figure out a different way to go about [the assessment and treatment]" (Justin Case).

Participants voiced a range of complimentary and constructive feedback about the learning intervention, with OFD 187 remarking,

> *Videos that are high quality cause the participants to feel immersed in the subject. …breaking it down the way we did there, I'd be very inclined to take [another class like this] one again, especially just because I'd be interested to compare it to see if it was as effective for me as yours was.*

And Jax appreciated putting together all the information presented, commenting,

> *I like the pauses, and you giving us the time to recap what was going on, like 'What just happened'? 'Did you guys catch this'? 'Did you guys catch that'? Giving us the opportunity to write down notes and to try to get our mind to kick in and key into some of the differential diagnoses.*

The participants seemed to overwhelmingly appreciate the discussions, and Akakael expounded on their significance:

> *I liked how you stopped [the video] often enough so that we would have discussions in between some of the scenes. We were watching part of a TV show and talking about treatment modalities and then moving on. I think if it would have been just the video without the pauses and the discussions, it wouldn't have been nearly as valuable. As I would wane paying attention to the video, is about the time that you would stop and make it an open discussion, which drew me back in.*

To end each interview, the participants were asked to finish the sentence: "Facilitated video case-based learning is…" Akakael stated, "a valuable tool that provides some critical thinking;" Tar O'Reilly answered, "effective. I was gonna say 'awesome,' but I think everybody else will use 'awesome;'" Jax declared, "beneficial in continuing education;" OFD 187 responded, "captivating and fun to participate in;" and Justin Case stated, "more engaging and easier to partake in than other forms of learning." And although Akakael added, "I will always take hands-on over video watching and discussions," in another question (Do you feel you learned less, as much, or more through facilitated video case-based learning than through other teaching methods?) he admitted that he learned "similar" with FVCBL. The other participants answered the same question by stating that through FVCBL they learned "more, because it keeps me engaged. I don't get bored" (Jax); "at least as much and probably more…I think it was more engaging for sure, so it helped me participate more and stay engaged" (Justin Case); "more" (OFD 187); and "more…I'm going to implement it into some [of my] training" (Tar O'Reilly). Finally, the participants answered that they were "somewhat likely" (Akakael); "likely" (Jax); "pretty likely" (Justin Case); "very interested" (OFD 187); and "I'm in" (Tar O'Reilly), to the question about how likely they were to sign up for future FVCBL classes.

Additional Coding

From the participant interview transcripts, the external coder developed four themes that aligned with the a priori categories in the deductive codebook. These included learner engagement and interaction, which aligned with the engagement subtheme; effectiveness of video-based learning, which aligned with the attitude subtheme; application to EMS practice, which aligned with both the confidence and commitment subthemes; learning retention and critical thinking, which aligned with the higher-order thinking theme.

Although the a priori categories were developed based on the literature, the same themes emerged organically from the participant data, which indicated that convergence was a sign of triangulation between the theoretical expectations and empirical reality.

DISCUSSION

Participants described the session as engaging, realistic, and relevant to their practice. A critical feature of facilitated video case-based learning was the ability to pause, reflect, and engage in structured dialogue, which created a space for learners to interrogate the clinical scenario collaboratively and foster deeper learning.

Participants consistently noted the realism of the clinical scenario, which enhanced their ability to visualize clinical presentations, identify patient care priorities, and consider differential diagnoses. This suggests that, when properly facilitated, video case-based learning can meet the criteria of a high-fidelity simulation. While fidelity traditionally refers to simulation's replicability of clinical reality, Rashid and Gianduzzo (2016) also characterize fidelity as encompassing the believability and contextual precision of the learning environment. By this definition, FVCBL achieved a high degree of fidelity, as it replicated not just the visual components of clinical care, but also its cognitive and emotional complexities.

Participants demonstrated clinical reasoning, differential diagnoses formulations, critical questioning, and application of theory to practice. The structured environment supported the cognitive shift from lower order thinking levels to more complex tasks such as analyzing, evaluating, and creating. Learners engaged in activities that required them to examine the case from interdisciplinary angles, formulate hypotheses, and refine their understanding in real time through peer and facilitator interactions. The instructional progression from case observation to active discussion and real-world application was central to HOTS development. The facilitation method strategically employed interrogation, redirection, and scaffolding, allowing learners to explore their reasoning paths while offering timely support.

Necessarily, the scenario's instructional design avoided over-complicating an already clinically challenging scenario. Perez et al. (2023) caution that overly complex or "unsolvable" cases can diminish learning and engagement. The present study addressed this by introducing complementary and supplemental information and/or alternative perspectives when learners encountered cognitive roadblocks, maintaining interest without compromising rigor.

Furthermore, the participants revealed that as the video played, they formulated their own questions and subsequently engaged in collaborative discussions while the facilitator posed complex open-ended questions. Chaojing (2023) emphasizes that such reflective practices help learners become more self-directed, adaptive, and capable of managing complexity in uncertain clinical contexts, which are all critical attributes in paramedicine.

Notably, all five participants expressed that the learning concepts would extend beyond the immediate session, especially in maintaining a high index of suspicion for underlying serious illness/injury even when all assessments are within normal limits. Recognizing that something is not right reflects a valuable form of prediagnostic awareness, often acquired through clinical experience and critical thinking, and is grounded in tacit knowledge and pattern recognition. By encouraging learners to focus on clinical deviation rather than definitive diagnoses, educators can cultivate curiosity, situational awareness, and reflective judgment. These enduring FVCBL qualities may very well sustain the learning for subsequent clinical application.

IMPLICATIONS FOR PRACTICE

The findings of this study suggest several key implications for the design and delivery of paramedic education. First, given that the participants found the video case study highly engaging and effective, educators should consider the integration of FVCBL as a central instructional approach in paramedic education, training, and ongoing workplace learning.

Second, FVCBL offers a scalable and cost-effective alternative to high-fidelity clinical simulation. When strategically integrated into course design and ongoing professional learning, video cases can maintain realism while reducing the costs associated with the staff (faculty, operations specialist, standardized patients), stuff (equipment, patient simulators, technology), and space (square footage, mobile trailer, utilities) (Senvisky et al., 2023) necessary for the execution of high-fidelity clinical simulation scenarios.

Third, there is an opportunity for educational institutions and paramedic training programs to produce their own clinically focused case-study videos and share them within their clinical and educational network. Such locally relevant content may improve contextual alignment with clinical practice and ensure coherence with institutional and national learning standards.

Next, training programs should incorporate structured opportunities for learner reflections and guided discussions within the video case presentations, to foster higher-order thinking skills. Facilitators should be trained in inquiry-based instructional strategies that promote student-led questioning, exploration, and collaborative reasoning, as the discussion component in FVCBL suggests that it is analogous to the debriefing component in clinical simulation, which is vital to learning (Grant, 2010; Okuda et al., 2009).

Finally, curricula should be designed to include video case scenarios that span varying levels of complexity to challenge learners at different stages of expertise. A progressive design approach allows for scaffolding of knowledge, skills, and abilities, supporting learners as they transition from novice to proficient clinician. Collectively, these implications highlight the potential for facilitated video case-based learning to serve as a transformative instructional strategy in paramedic learning.

RECOMMENDATIONS FOR FUTURE RESEARCH

Future studies should compare facilitated video case-based learning with other instructional approaches, for example, traditional lectures, hands-on clinical simulations, flipped classrooms, game-based learning, and experiential learning. FVCBL should also be examined for its adaptability to various educational formats, including online and hybrid settings, which may help support more scalable, flexible, and inclusive training opportunities for remote learners. FVCBL's group composition (varying skill levels), size, and diversity should also be investigated to gauge their effects on collaborative learning, engagement, and critical thinking. Additionally, given the importance of the structured discussions, future studies should examine how different facilitation skills and styles affect learner engagement, critical thinking, and knowledge retention.

Finally, further investigation is needed to determine whether the competencies developed through FVCBL transfer effectively to real-world clinical decision-making in paramedicine. Specifically, behavior and results, corresponding to levels 3 and 4, respectively, of the New Kirkpatrick Model®, should be evaluated to assess the broader impact of FVCBL on paramedic performance and patient outcomes.

LIMITATIONS

The study was limited by a relatively small sample size in one fire department; however, the sample size was purposefully kept at the level in which clinical simulation has been shown to be most effective, which is five participants (Au et al., 2023). Another limitation was that the structured classroom environment does not fully replicate the dynamic, high-pressure context of real-world paramedic emergencies. Finally, the dual role of the researcher as both facilitator and interviewer introduced the possibility of observer bias and participant reactivity. Since the participants were volunteers, they were probably self-motivated in seeking further education and inclined to consider the learning intervention as worthwhile. While self-reported data is valuable for understanding learner

perceptions, it may be influenced by the participants' desires to meet perceived expectations.

CONCLUSION

This study explored the impact of facilitated video case-based learning within paramedic workplace learning. The findings revealed that FVCBL learning was not only perceived as highly engaging and relevant but also contributed meaningfully to knowledge acquisition and the development of higher-order thinking skills.

Participants consistently emphasized the value of the realistic case scenario and structured facilitation in deepening their understanding and application of clinical practice and protocols. These findings suggest that FVCBL holds significant potential as a pedagogically robust and scalable alternative to more resource-intensive teaching and learning strategies, such as high-fidelity clinical simulation.

As paramedic learning continues to evolve, instructional strategies like FVCBL can offer a flexible, cost-effective, and comprehensive strategy for preparing paramedics for real-world medical emergencies. This study contributes to a growing body of evidence supporting the use of case-based, technology-enhanced learning modalities in paramedic and health professions education. It affirms the potential of facilitated video case-based learning to enrich paramedic learning, foster reflective and critical thinking, and ultimately improve clinical acumen and patient outcomes.

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EXPLORING UNIVERSITY EDUCATION VARIATION: A MIXED-METHODS SURVEY OF AUSTRALIAN AND AOTEAROA NEW ZEALAND UNDERGRADUATE PARAMEDICAL ELECTROCARDIOGRAPHY CONTENT

Matt Wilkinson-Stokes, PhD, BP(H1M)*[1]; Sonja Maria, PhD[2]; Nigel Barr, PhD[3]

Author Affiliations: 1. Faculty of Medicine, Dentistry, and Health Sciences, University of Melbourne, Melbourne, VIC, Australia; 2. School of Nursing, Paramedicine, and Healthcare Sciences, Charles Sturt University, Bathurst, NSW, Australia; 3. School of Health, University of the Sunshine Coast, Sippy Downs, QLD, Australia.

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Disclosures: SM is an editor at IJOP; there was no author involvement in editorial decisions for this manuscript, and peer review was double blinded. All authors have previously been involved in the education of undergraduate paramedics, including having previously taught electrocardiography. The institutions SM and NB are affiliated with were participants in this project, with their responses anonymized at point of collection. To minimize any perception of conflict, analysis was primarily conducted by a researcher from a non-participating institution, MWS, and both data and R code for reproducibility of analysis are available online. Ethical approval was granted by the University of the Sunshine Coast Human Research Ethics Committee (approval A242245).

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Data Availability: All data and software code are available. The dataset can be found on FigShare (https://figshare.com/articles/dataset/Dataset_xlsx/29387729). R Code, including brief instructions on how readers can reproduce the analysis for themselves, is provided in the Appendix.

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**Corresponding Author:*
matt.wilkinson-stokes@outlook.com

ABSTRACT

In Australia and Aotearoa New Zealand, statutory registration bodies define the capabilities expected of graduate paramedics but do not prescribe a minimum curriculum. Consequently, the extent to which universities differ in the content they teach is unknown.

Aim: To determine the depth of teaching and degree of overlap in electrocardiography content across university paramedicine programs.

Methods: A custom-designed mixed-methods survey comprising 377 electrocardiography topics and free-text questions was developed through a five-stage design and pretesting process. Fourteen of the eighteen eligible university programs participated (78%). Quantitative curriculum overlap was assessed using Simple Matching Coefficients, while qualitative responses underwent content analysis.

Results: Considerable variation was identified across university curricula. 66% of topics were taught by some universities and not by others, 30% were taught by all universities but to differing depths, and 4% were approached the same across all universities. Average university curriculum overlap was modest (52%, IQR 47%-60%). Qualitative responses reflected uncertainty regarding the appropriate breadth of undergraduate electrocardiography education, with participants describing it as "hard to know if we are teaching too much or not enough" and calling for a "standardized minimally accepted practice level."

Conclusion: There is a high level of heterogeneity in electrocardiography education in undergraduate paramedicine programs in Australia and Aotearoa New Zealand. This includes content with significant patient safety risks. Development of a standardized minimum curriculum would provide educators and employers with certainty about expected graduate electrocardiography capabilities and may improve patient safety.

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INTRODUCTION

Across Australia and Aotearoa New Zealand, there are currently 18 active university programs accredited by Ahpra or Te Kaunihera to prepare graduates for initial paramedicine registration (Te Kaunihera Manapou, 2024; Paramedicine Board of Australia, 2026). To gain accreditation, universities must demonstrate that their programs enable graduates to meet the standards set by the Ahpra Paramedicine Board of Australia (PBA) or Te Kaunihera Paramedicine Council (Te Kaunihera Manapou, 2024; Paramedicine Board of Australia, 2026). These regulatory standards are intentionally high-level.

The PBA provides a list of "professional capabilities for registered paramedics", which contains five broad domains, made up of twenty-one capabilities (Paramedicine Board of Australia, 2021). Domains capture broad groupings of capabilities such as "the paramedicine practitioner", while the capabilities within domains capture similarly broad skills such as "understand the key concepts of the bodies of knowledge which are specifically relevant to paramedicine practice" (Paramedicine Board of Australia, 2021, p. 9). Universities must supply evidence that their programs support student attainment of these capabilities—for example, "understand the structure, function and pathophysiology of the human body" (Paramedicine Board of Australia, 2021). Te Kaunihera's Standard of Cultural Safety and Clinical Competence for Paramedics mirrors these domains and capabilities closely, having been explicitly adapted from the PBA framework (Te Kaunihera Manapou, 2020). This outcomes-based structure is intentionally flexible and allows institutions to design curricula that suit their pedagogical philosophy and local workforce needs.

However, the mandated level of curricular detail stops here. It is at this intersection of capability-based regulation and curriculum design that a significant tension emerges. While the capabilities describe broadly what graduates must be able to do, they do not specify what content should be taught, or to what depth. No minimum curriculum is mandated by the PBA or Te Kaunihera. This omission may have important implications: in many health professions, clearly defined minimum curricula function as mechanisms to ensure baseline competence, enabling consistent assessment of essential knowledge and skills—and ultimately supporting safer and more equitable patient outcomes (Arja et al., 2024; World Health Organization, 2013).

Although this flexibility has advantages, it also raises an important question: does curriculum autonomy result in meaningful differences in the clinical knowledge possessed by graduates? Such variation has been raised previously. In 2000, Lendrum et al. stated: "the actual course content is variable… there is no published evidence that ambulance personnel are trained appropriately or that defines appropriate training" (Lendrum et al., 2000, p. 7). In a 2017 editorial, Boyle stated: "Even though university paramedic courses are currently accredited… there is still a variation in the standard of paramedic courses and paramedic graduates" (Boyle, 2017, p. 1). Perhaps more starkly, in 2024 an Australian undergraduate course coordinator stated: "I don't know what the hell we're supposed to be teaching them? I'm just not too sure what paramedics do" (Wilkinson-Stokes et al., 2024, p. 12).

Before policy responses can be considered, the extent of any variation must first be quantified. To date, no published literature has examined the extent of content variation

across accredited paramedicine programs. This study addresses that gap by providing an initial quantitative exploration of curriculum depth using electrocardiography as an exemplar. Three considerations informed the choice to use electrocardiography as the study topic.

Firstly, one motivating factor for this research was an unpublished sentinel event in which a graduate paramedic attempted to administer tenecteplase to a teenage patient with Brugada pattern (Coppola et al., 2021). Having never been taught the pattern (but now authorized to autonomously administer lysis by virtue of registration as a paramedic), they mistook it for septal ST elevation and misdiagnosed an acute left anterior descending occlusion. A similar incident of ECG misdiagnosis in the UK resulted in the death of a 29-year-old woman. This led to a coroner's investigation (Lees, 2023) and in turn to an ongoing investigation into paramedic electrocardiograph abilities (Health Services Safety Investigations Body, 2024). This has so far identified at least three preventable deaths from paramedic misinterpretation of electrocardiographs (Health Services Safety Investigations Body, 2025). However, the rationale for this study extends beyond individual incidents and reflects broader questions regarding consistency of educational preparation under capability-based accreditation models.

Secondly, electrocardiography is considered a fundamental skill for paramedics, having been described as "critical" (Mobrad, 2020, p. 824), "important" (Williams et al., 2008, p. 526), "a priority" (Wyld et al., 2023, p. 496) and "an essential competency in modern paramedicine" (Sibley et al., 2021, p. 1). Accordingly, ECG interpretation is taught universally across programs, making it a suitable comparator through which to examine program-level variation.

Finally, ECG interpretation is a conceptually complex area for education (Bishop and Meadley, 2025), and even medical degrees struggle to cover it comprehensively at undergraduate level (Viljoen et al., 2020). Consequently, educators must make decisions about which specific ECG concepts to include, emphasize, or omit. This natural process of pedagogical prioritization creates an ideal environment for exploring whether the capability-based accreditation model leads to meaningful differences in curricular scope.

This study therefore uses electrocardiography as a case study to interrogate the broader challenge inherent in capability-based accreditation: whether high-level regulatory standards, in the absence of a defined minimum curriculum, may inadvertently permit unsafe variation in graduate capabilities. By mapping the content and depth of ECG instruction across all accredited paramedicine programs in Australia and Aotearoa New Zealand, this research aims to identify whether meaningful differences exist and whether these differences warrant policy or curricular reconsideration. The findings will be of relevance to regulators, educators, and employers, as the paramedicine sector seeks to balance flexibility and public protection within a maturing professional landscape.

AIM

This project aims to explore variation in the teaching of electrocardiography within Australian and Aotearoa New Zealand entry-to-practice paramedicine programs. Specifically, it seeks to answer the questions:

- What is the proportion of predefined electrocardiography topics taught across different programs?
- To what depth are topics taught across different programs?
- What is the degree of overlap and variation in content across different programs?
- What are the opinions of lecturers on tertiary content variability?

METHODS

This study uses a concurrent, mixed-methods design (quantitative focus, with an embedded qualitative component). As no validated instrument exists to quantify the breadth and depth of electrocardiography curricula across undergraduate paramedicine programs, a bespoke survey was developed specifically for this study. Questions were primarily multiple-choice, with nested free-text boxes for open-ended participant commentary and unanticipated responses (Story & Tait, 2019). The survey was designed in five stages between February and November 2024 using established methods (De Vaus, 2013; O'Cathain & Thomas, 2004; Peterson, 2000; Story et al., 2011; Story & Tait, 2019; Tait & Voepel-Lewis, 2015).

Firstly, existing undergraduate and postgraduate paramedicine university course materials across three institutions were combined to develop a comprehensive three-tier taxonomy of electrocardiography content that organized content as 10 "subjects" (e.g. "12/15/16 lead analysis"), 68 "groups" (e.g. "Imposters/mimics") and 377 "topics" (e.g. "Brugada Sign Type 1"). This taxonomy formed the skeleton of the quantitative data collection and is provided in the Appendix. To reduce the likelihood of acquiescence bias (i.e. breaking the habit of participants selecting that all topics are taught by forcing them to acknowledge some topics are not), content historically included in postgraduate courses (taught at the critical care paramedic level) was explicitly included. This was also anticipated to assist in distinguishing where universities were differentiating; as there is no minimum undergraduate content some universities may be including content historically taught to postgraduates as part of the undergraduate degree, which this approach sought to capture.

Secondly, an initial survey and set of instructions were developed using these as the content by one researcher (MWS). The survey was designed to include exhaustive and mutually exclusive closed-ended questions, with free-text fields regularly added to allow participants to provide unanticipated responses (Tait & Voepel-Lewis, 2015). Topics were able to be categorized into one of five categories to capture if they were taught, and if so to what depth; this categorization is outlined in Table 1. To maximize consistency in interpretation, each category was accompanied by a standardized written definition and illustrative examples within the survey. Participants were instructed to base responses on the 2024 teaching year after reviewing historical teaching materials where necessary, and the wording of all categories was refined through iterative expert piloting and pretesting with members of the target population. The categories were intentionally hierarchical, representing increasing educational depth from "Not taught" through to "Assessed", thereby providing mutually exclusive levels of curriculum exposure.

Thirdly, the survey materials were pretested on the remaining research team (SM, NB). This included reviewing the order and flow of questions, ambiguity, and time to complete. Fourthly, three content experts piloted the survey: a critical care paramedic and educator, a second critical care paramedic, and a community paramedic with postgrad-

uate qualifications in urgent-primary care and experience as an educator. Fifthly, the survey materials were pretested on 11% of the target population (Story & Tait, 2019); two university lecturers who recently taught electrocardiography to undergraduates. The five content experts and recent participants were interviewed either via telephone or email post-survey, with the opportunity to provide specific feedback on any aspect of the survey (feedback summarized in the Appendix). Pretesting suggested high face validity and content validity. From this, the results of pretesting were discussed among the research team, and the final design was confirmed. Given that the participants were university lecturers, common acronyms were used where appropriate.

Categorization		Definition Provided to Participants
Taught	Assessed	"Assessed" means that the topic is considered key for undergraduate paramedics and, as well as being taught in theory and practiced, appears on formal assessment, including on examinations, assignments, or OSCEs.
		Many universities have statements akin to "all content within the learning material is assessable". We encourage you to review which of these topics were historically taught as theory, practiced, or assessed during the 2024 teaching year.
	Practiced	"Practiced" means that a topic is discussed in theory, and additionally practically applied by students themselves in any of tutorials, simulations, labs, or hands-on skills classes.
		For example, a student may be asked to assess an ECG in a non-exam environment like a tutorial, or the topic may be part of class discussions or group work.
	Theory only	"Theory only" means that the topic appears in teaching materials, such as lecture slides, but students do not practice applying this in a classroom setting.
		For example, students may be expected to be familiar with a concept but aren't expected to practice applying it in the classroom.
Not taught	Not taught	"Not taught" means that the topic is not formally discussed in any teaching materials.
Null response	Unsure / Taught elsewhere	"Unsure / taught elsewhere" means that the topic is taught in a separate unit by other staff, and you are not sure if it is taught or the depth it is taught to.
		This functioned as a null response and was excluded from analysis.

Table 1. Categories of topics available to participants.
Note. ECG: electrocardiograph; OSCE: objective structured clinical examination.

Finally, at the conclusion of the survey, participants were provided with an additional free text box and the question "We are not yet sure if there are any meaningful variations across electrocardiography undergraduate course content. If there are or aren't, what are your thoughts on this topic?" The full survey remains available online to ensure reproducibility (https://q.surveys.unimelb.edu.au/jfe/form/SV_9GCQ3O5XT5aj0Mu). Transcribed free-text responses were independently coded by all three researchers using an inductive approach; emergent codes were identified iteratively, and disagreements were resolved through discussion until consensus was reached. Triangulation was used to integrate and compare findings from the quantitative and qualitative components of the study, enhancing the completeness and credibility of research findings (Mertens and Hesse-Biber, 2012). This study is reported in accordance with the Consensus-Based Checklist for Reporting of Survey Studies (CROSS) (Sharma et al., 2021).

Survey Recruitment

All 18 universities in Australia and Aotearoa New Zealand that provide active Bachelor level paramedicine programs were invited to participate (Te Kaunihera Manapou, 2024; Paramedicine Board of Australia, 2026). The sampling frame therefore overlapped entirely with the target population. Two additional institutions provide only graduate diploma

programs; these have been excluded due to uncertainty about the expected prior knowledge of students, and consequently that these are a distinct population and inclusion would confound results.

Prior to the design of the study, in January 2024 all 18 target universities were directly contacted via telephone, and a relevant lecturer was spoken to. This allowed prima facie willingness to participate to be gauged, to determine if the study was feasible, and to minimize the risk of low response rates leading to survey responder bias. After completing the survey design and ethical approval, between January and April 2025 participants were re-contacted and formally recruited. Where electrocardiographs were taught across multiple units, the unit coordinator of the final unit was recruited (as it was considered that they would have the best overall view of the cumulative content taught across the degree). Each unit coordinator was video conferenced or teleconferenced, and the project was discussed. Those who proceeded to participate signed a written Consent Form before being provided with the survey. As the sampling frame comprised all eligible universities, the principal remaining source of selection bias was voluntary non-participation rather than sampling error.

ANALYSIS

Prior to analysis, the validity of the results was considered based on the response rate, representative sampling, and non-responder bias, with a response rate of >40% considered acceptable (Story et al., 2011; Story & Tait, 2019). The data corpus was imported into R. Consistent with the study aims, descriptive statistics were used to quantify curriculum coverage, pairwise similarity coefficients were used to measure curriculum overlap between institutions, and qualitative content analysis was used to identify common perspectives expressed in free-text responses. Each of the 10 subjects, 68 groups, and 377 topics was assessed by the frequency of different categories, along with overall institution percentages and stacked bar charts for visualization. Each university was then compared against the other universities in a pairwise matrix of 91 comparisons of the 377 topics (for a total of 34,307 possible comparisons), with Simple Matching Coefficients (SMC) used to index the similarity. R code is provided in the Appendix.

Because the primary aim was to determine whether institutions approached individual topics identically rather than measure the magnitude of disagreement, a categorical similarity measure was selected. The SMC is a similarity measure for categorical data (Sokal and Michener, 1958; Warrens, 2008) that permits intuitive interpretation of overlap between programs. Unlike distance measures that weigh disagreement differently, SMC was selected because the research question concerned exact agreement between institutions (Warrens, 2008). While similar previous research used the Jaccard coefficient (Were et al., 2021), we intentionally differed and used the Simple Matching Coefficient (SMC). This was because agreement between two universities in not teaching a topic was considered a meaningful similarity in curricular approach, particularly given that the survey included postgraduate-level content. Unlike the SMC, the Jaccard coefficient excludes joint absences from the calculation and would therefore not capture this. The SMC calculation is shown in Figure 1.

Practically, the Simple Matching Coefficient was calculated by excluding comparisons containing null responses, coding each topic comparison between two universities bi-

$$Simple\ Matching\ Coefficient = \frac{Number\ of\ matching\ attributes}{Total\ number\ of\ attributes}$$

Figure 1. SMC calculation.

narily (1 for identical responses and 0 for different responses), and dividing the number of identical responses by the total number of valid comparisons. This produced a coefficient ranging from 0 (completely dissimilar) to 1 (completely identical). The distribution of the 91 pairwise coefficients was then examined and visualized using a heatmap and violin plot with a nested boxplot. SMCs are an index, however here they have been presented as percentages to aid in reader interpretation.

For the qualitative question "What are the opinions of lecturers on variation in tertiary subject content?", content analysis was performed by three researchers (MWS, SM, NB) to systematically code and categorize open-ended survey responses to identify patterns and themes (Hsieh and Shannon, 2005).

ETHICS

Ethical approval was granted by the University of the Sunshine Coast Human Research Ethics Committee (approval A242245). The main ethical risk considered during design was the reputational risk from data being construed to suggest that some universities are more thorough, or perceived to have more comprehensive teaching, than others. To minimize this risk, which universities participated is not stated and responses were anonymized at the point of collection.

RESULTS

Of the 18 universities, 17 (94%) consented to participate. Of these, 14 (78% of the target population, 82% of participants) returned complete surveys, a high response rate that is suitably representative of the target population. The low dropout rate (18%) suggests minimal risk of attrition bias. "Unsure / Taught Elsewhere" responses and blanks were treated as null data and omitted from all calculations. These comprised 4.5% of all responses (n=238 of 5,278 topic-level responses) and less than 13% of responses for any of the 10 subjects (average 5%, range 0-12%), suggesting minimal impact on the reliability of results.

Two atypical response patterns were observed. University 7 reported that nearly all electrocardiography topics were assessed, whereas University 11 reported that no electrocardiography topics were assessed. University 11's responses were supported by contemporaneous free-text comments explaining that electrocardiography was intentionally not assessed within that university, thereby providing contextual corroboration for the unusual response pattern. In contrast, no equivalent explanatory information was available for University 7. Because the survey was anonymous, it was not possible to seek clarification or independently verify the unusually high proportion of assessed topics. Consequently, University 7 responses were retained in the primary analysis (as there was no objective basis for exclusion), with a sensitivity analysis excluding the results undertaken. This sensitivity analysis produced no meaningful change in the findings, supporting the robustness of the results.

Quantitative Results

Of the 377 topics surveyed no topic was taught, and taught at the same depth, by all responding universities. 15 (4.0%) were not taught at all responding universities. A further 114 topics (30.2%) were taught by all responding universities but to differing depths, while 248 (65.8%) were taught by some universities and not taught by others. Overall findings are summarized in stacked bar graph form in Figure 2.

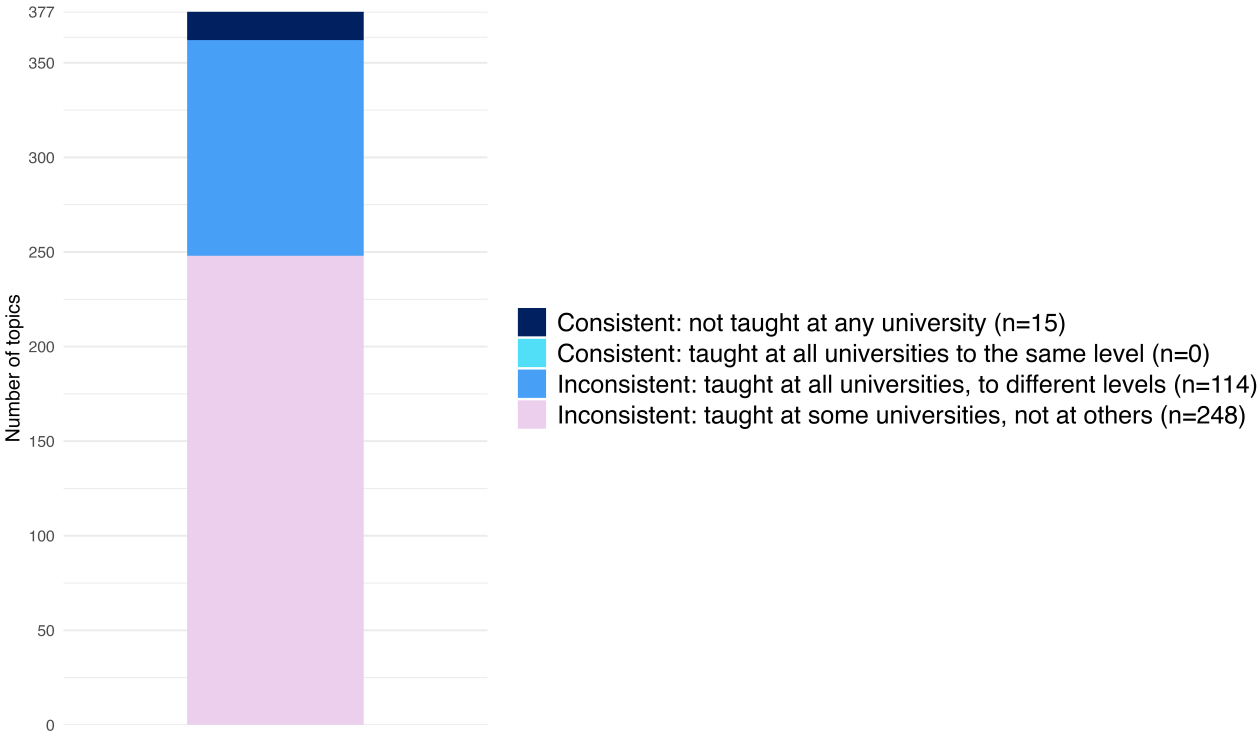


Figure 2. Consistency of topics across all 14 institutions.

Table 2 provides an example of responses below and illustrates how numerical results were derived from categorical responses. It shows the responses for the "equivalents" group—electrocardiographic patterns that may indicate occlusive infarction amenable to reperfusion but that present differently from basic ST-segment elevation (Asatryan et al., 2019). Listed below the responses for each university are the numerical and percentage results, with the percentages excluding null responses. Full results are available in the dataset published online (https://figshare.com/articles/dataset/Dataset_xlsx/29387729).

Each university pair's topic coverage was compared to generate a matrix of SMCs, provided as a pairwise matrix in Table 3 and visualized as a heatmap in Figure 3.

Across the 91 pairwise university comparisons, the mean SMC was 52%, with a median of 54%, and an interquartile range of 47%–60%. This means that any two universities, on average, teach approximately half of their content the same. The minimum, between Universities 7 and 11, was just 1% (near perfect dissimilarity): across all 377 topics, these two institutions had the same approach to just 3 topics. The maximum, between Universities 7 and 14, was 90%: these two institutions had the same approach to 239 topics. However, as discussed, University 7 may be an incorrect response. If University 7 is omitted, the

Topic	Example of Responses, Using the ACOMI-STEMI Equivalents Topic								
Sub-Topic	Equivalents Generally	Reciprocal Changes Only Visible - Posterior or Isolated RVMI	LMCAO	New Left Bundle	New Left Bundle - Smith Modified Sgarbossa	Wellens - Type A	Wellens - Type B	de Winter	Aslanger
University 1	Theory only	Theory only	Theory only	Theory only	Not taught	Theory only	Not taught	Theory only	Not taught
University 2	Practiced	Practiced	Unsure / taught elsewhere	Practiced	Assessed	Practiced	Practiced	Unsure / taught elsewhere	Unsure / taught elsewhere
University 3	Not taught	Not taught	Not taught	Not taught	Not taught	Not taught	Not taught	Not taught	Not taught
University 4	Theory only	Assessed	Not taught	Not taught	Not taught	Assessed	Assessed	Assessed	Not taught
University 5	Assessed	Theory only	Theory only	Theory only	Theory only	Theory only	Theory only	Theory only	Theory only
University 6	Not taught	Not taught	Not taught	Not taught	Not taught	Not taught	Not taught	Not taught	Not taught
University 7	Assessed	Assessed	Assessed	Assessed	Assessed	Unsure / taught elsewhere	Unsure / taught elsewhere	Unsure / taught elsewhere	Unsure / taught elsewhere
University 8	Not taught	Assessed	Theory only	Not taught	Assessed	Not taught	Not taught	Not taught	Not taught
University 9	Practiced	Practiced	Not taught	Assessed	Practiced	Practiced	Practiced	Practiced	Not taught
University 10	Assessed	Assessed	Assessed	Assessed	Theory only	Theory only	Theory only	Assessed	Theory only
University 11	Theory only	Not taught	Not taught	Theory only	Not taught	Theory only	Not taught	Not taught	Not taught
University 12	Assessed	Theory only	Theory only	Theory only	Theory only	Assessed	Theory only	Theory only	Not taught
University 13	Practiced	Not taught	Practiced	Practiced	Practiced	Practiced	Practiced	Practiced	Not taught
University 14	Assessed	Assessed	Assessed	Assessed	Assessed	Theory only	Theory only	Theory only	Unsure / taught elsewhere
Summaries (note: summary percentages only include A/P/T/NT responses; U responses are excluded)									
Assessed	**5 (36%)**	**5 (36%)**	3 (23%)	**4 (29%)**	4 (29%)	2 (15%)	1 (8%)	2 (17%)	0 (0%)
Practiced	3 (21%)	2 (14%)	1 (8%)	2 (14%)	2 (14%)	3 (23%)	3 (23%)	2 (17%)	0 (0%)
Theory only	3 (21%)	3 (21%)	4 (31%)	**4 (29%)**	3 (21%)	**5 (38%)**	4 (31%)	**4 (33%)**	2 (18%)
Not taught	3 (21%)	4 (29%)	**5 (38%)**	**4 (29%)**	**5 (36%)**	3 (23%)	**5 (38%)**	**4 (33%)**	**9 (82%)**
Unsure	0 (0%)	0 (0%)	1 (7%)	0 (0%)	0 (0%)	1 (7%)	1 (7%)	2 (14%)	3 (21%)

Table 2. Education of occlusive myocardial infarction equivalent patterns.

	2	3	4	5	6	7	8	9	10	11	12	13	14
1	42%	51%	59%	47%	57%	37%	51%	47%	42%	41%	52%	54%	44%
2		59%	54%	67%	48%	69%	63%	51%	61%	23%	64%	55%	68%
3			59%	60%	58%	60%	66%	55%	56%	29%	59%	55%	56%
4				55%	57%	54%	61%	51%	54%	28%	50%	51%	54%
5					50%	68%	64%	49%	62%	28%	71%	54%	67%
6						40%	51%	53%	42%	38%	49%	56%	46%
7							71%	42%	81%	1%	70%	44%	90%
8								49%	59%	27%	63%	50%	67%
9									47%	37%	48%	53%	47%
10										20%	67%	49%	74%
11											27%	33%	15%
12												54%	70%
13													47%

Table 3. Pairwise matrix of simple matching coefficients.

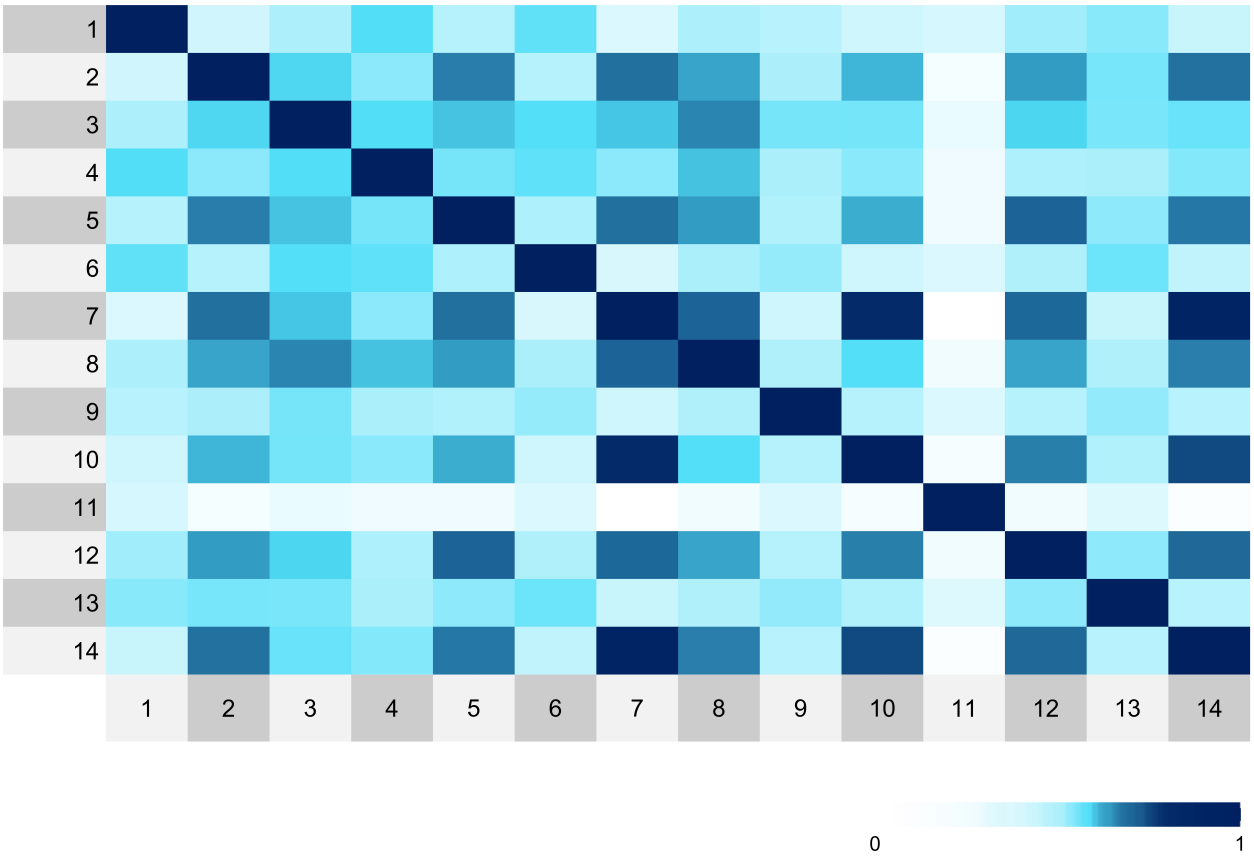


Figure 3. Heatmap of simple matching coefficients.

mean drops to 51%, with a median of 53%, an interquartile range of 47%–59%, and a range of 15%–74%; omitting University 7 has no meaningful impact on overall metrics. The spread of coefficients is provided in Figure 4.

Figure 5 illustrates the relative depth of teaching at each university. This graph omits null responses, therefore providing totals below the 377 topics surveyed. This graph also illustrates the differing approaches to education across institutions: while several are assessment-heavy, at least one was confirmed to use no assessment at all.

If University 7's results are excluded, the highest possible level of conflict—in which at least one university does not teach a topic at all, while at least one other university included it in their assessments—is present for 55% of topics (n=208). These 208 topics are visible in the online dataset.

Qualitative Results

Of the 14 responses received, 5 (36%) provided additional commentary. Participants noted uncertainty and expressed concern about what they should be teaching, stating: "At the moment, it's hard to know if we are teaching too much or not enough" (University 1) and "We feel as if there are significant variations across tertiary institutions" (University 5).

The need to distinguish what curriculum should be included across different capability levels was raised: "We also need differentiations of skill levels. i.e., all paramedics can obtain and assess 12 Lead ECG for dysrhythmias and ACS. All 'intensive care/equiva-

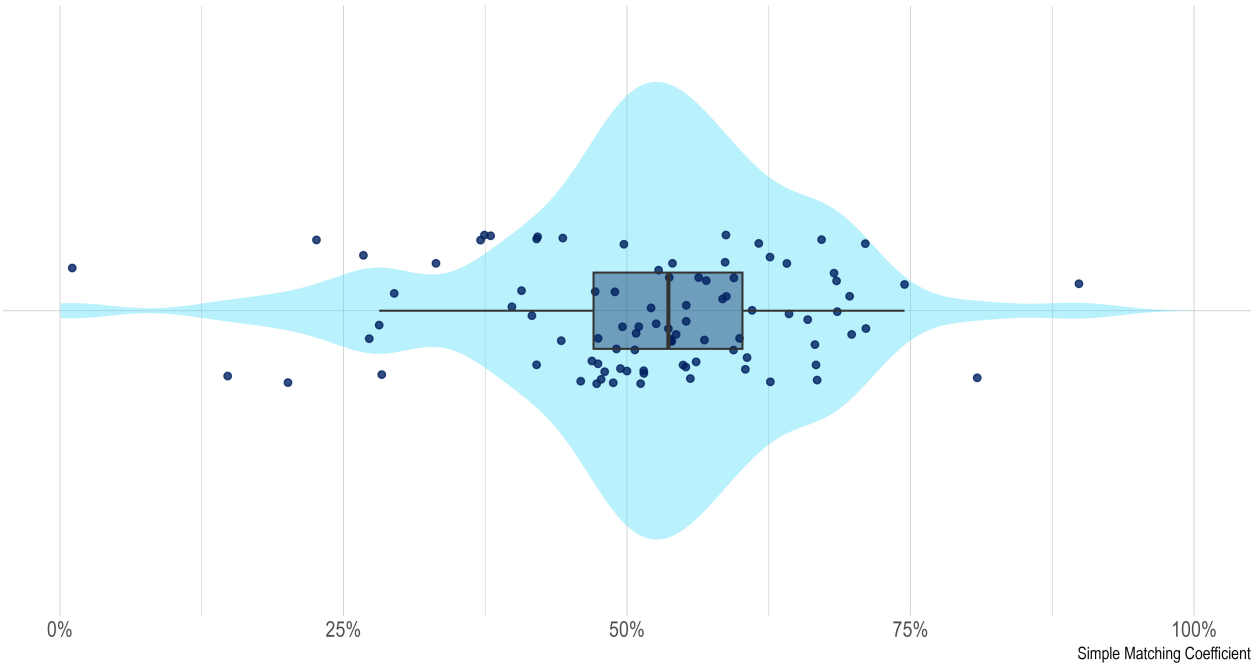


Figure 4. Violin Plot with Nested Boxplot of Simple Matching Coefficients.

lent' paramedics can . . . whatever the next level is decided to be" (University 2) and "Just because some of the topics have been taught to that level in this course, it does not necessarily reflect where the standard should be at an undergraduate level" (University 14).

One university stated they explicitly include more complex content due to their higher student admission scores: "Our student entry requirements are very high, which means we can cover more content with our students" (University 10).

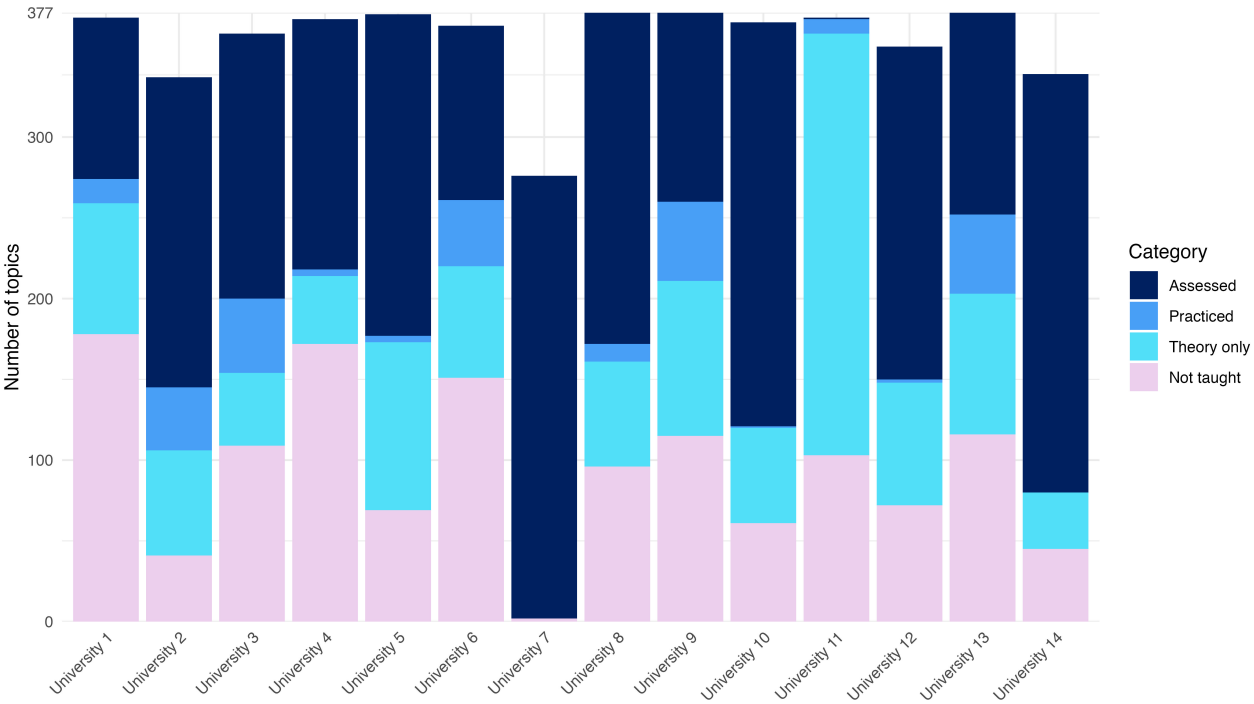


Figure 5. Number of topics in each category by University.

Finally, lack of regulatory guidance was noted: "It would be great to have literature recommending a certain level of ECG knowledge required for undergraduate students" (University 1) and "As with many areas of paramedicine, the lack of guidance from Ahpra will make this a challenge to address. There should be a standardized minimally accepted practice level for ECGs in paramedicine in Australia" (University 2).

Triangulation

The nested qualitative responses provided some explanation for the quantitative findings. The quantitative data showed a very high level of heterogeneity in course content, with the mean similarity across topics being just 52%. The qualitative response echoed this: participants were unsure of what topics they should be teaching undergraduates. The qualitative also linked differing entry requirements with differing student abilities, suggesting courses with higher entry scores intentionally include content beyond what they consider the "minimum standard" to practice as a registered paramedic. This "minimum standard", however, does not appear well-defined: across all institutions, there were just 15 of 377 sub-topics taught to the same depth. Cumulatively, these results suggest that undergraduate paramedicine electrocardiography education in Australia and Aotearoa New Zealand is highly inconsistent, and that a standardized minimum curriculum is sought by educators.

DISCUSSION

To our knowledge, no previous published study has quantified any potential inconsistency across Australian and Aotearoa New Zealand undergraduate paramedicine university program content. These findings provide the first empirical evidence to date of inconsistency in the field of electrocardiography education. The results of this paper demonstrate a high level of inconsistency in topics taught—with an average of 52% similarity and, in one instance, a near-perfect dissimilarity of 1%. Most concerningly, this heterogeneity extends to topics with direct life-threatening patient safety implications. For example, the Smith-modified Sgarbossa criteria for identifying a heart attack were part of final assessment in four universities but not taught at all in five others.

However, this research does not explain why variation is present. Speculatively, this phenomenon likely emerged as each university currently develops its course topics independently, with regulatory standards for courses being high-level and lacking specificity regarding individual topics. Teaching materials are rarely open access, being sometimes considered the intellectual property of the university and sometimes the intellectual property of the creating staff (Jamali, 2024). This legal barrier inhibits comparison across facilities by staff, potential graduate employers, or students, leading to uncertainty as to the topics covered. This appears to be compounded by an uncertain professional identity within the discipline as paramedicine moves out of its traditional ambulance-based roles (Corman et al., 2025; Eastwood et al., 2023).

Similarly, educational requirements provided to universities by regulators are reasonably abstract—for example, that graduates can "understand the structure, function, and pathophysiology of the human body" (Paramedicine Board of Australia, 2021), providing minimal practical guidance for educators. The standards of Ahpra and Te Kaunihera do not, for example, specify that courses are required to teach any cardiology. More specifically, there is no written requirement that undergraduate paramedicine programs

teach electrocardiography, nor any mandated list of ECG topics such as interpretation of 12/15/16-lead electrocardiographs, or the detail that may in turn lie beneath these, such as identification of occlusion equivalents such as de Winter (de Winter et al., 2008), Aslanger (Aslanger et al., 2020), or Wellens (Rhinehardt et al., 2002). This high-level approach has allowed circumstances to emerge where one university does not assess knowledge of electrocardiographs, but where all graduates may be registered to practice autonomously—including providing interventions based on ECG interpretation—without their knowledge for safe practice being confirmed.

Participants frequently described uncertainty regarding whether they were teaching too much or too little. This uncertainty is an important finding. Rather than reflecting disagreement about educational philosophy, in the context of this study it suggests the absence of an agreed benchmark against which curricula can be calibrated. In professions with defined minimum curricula, educators can compare their teaching against nationally accepted expectations. In contrast, the absence of such benchmarks may leave curriculum decisions dependent on educator expertise and historical practice. Reasonable educators may therefore arrive at markedly different curricular decisions while remaining fully compliant with accreditation standards.

Course benchmarking, a requirement under the Higher Education Standards Framework in Australia, may offset these risks by providing some basic level of consistency across different institutional courses (Tertiary Education Quality and Standards Agency, 2024; Department of Education, Skills and Employment, 2021). Course benchmarking compares course design and student performance across institutions; this usually includes comparison of admission criteria, assessment tasks, student work samples, and assessment criteria (Tertiary Education Quality and Standards Agency, 2024). However, it does not routinely include topic comparisons or the depth to which these topics are taught. A second mechanism that may provide some consistency is the movement of academics between institutions; however, this occurs on an ad hoc basis and cannot be considered a reliable means of establishing standards.

Although electrocardiography was selected as the exemplar because of its clinical importance and conceptual complexity, the findings have implications beyond ECG education. Any knowledge domain lacking a prescribed minimum curriculum is susceptible to similar variation. Consequently, the results raise broader questions regarding whether capability-based accreditation alone is sufficient to ensure consistent graduate preparation across the profession.

However, there are valid competing arguments against establishing a minimum curriculum to address this. Firstly, regulators may additionally be concerned that establishing standards may inadvertently constrain the progression of the profession into novel areas if it were treated as a ceiling rather than a baseline. Additionally, the argument for some baseline standards for electrocardiograph content in this paper is built on the assumption that all graduate paramedics should be taught electrocardiographs. Despite the earlier statements that it is often considered fundamental for clinical practice, no definitive source states that a graduate must be competent in electrocardiography to be a paramedic. Is knowledge of electrocardiographs required to become a "paramedic"? The current regulatory position is: no.

Secondly, the purpose of a university is not to simply teach a memorizable list of content or skills—an approach more reflective of vocational education (Blake et al., 2003; Moore & Morton, 2017). Universities instead focus on theory underpinning practice (Blake et al., 2003). However, over the previous decades, there has been an increasing movement within the tertiary education sector to produce "job-ready" graduates with a practical and relevant skill set to employment, including incentives by the Australian Government (notwithstanding the Australian University Accords recommendation to step back from this approach) (Blake et al., 2003; Daly & Lewis, 2020; Tomlinson, 2012).

Despite these counterarguments, having no minimum educational standards for safe practice has undeniable safety risks when paramedics are making autonomous ECG interpretations, as illustrated by the three deaths reported in the UK. The 2025 UK report explicitly identified confusion regarding the expected knowledge of paramedics and stated that there is no formal requirement for whether ECGs should be taught, how they should be taught, or to what standard (Health Services Safety Investigations Body, 2025).

While the UK's industry college has previously provided some brief, non-binding guidance for paramedics (College of Paramedics, 2024), no such statement exists within Australian or Aotearoa New Zealand paramedicine. This is despite the proven impact of autonomous paramedic interpretation and subsequent lysis or catheterization lab activation in improving clinical outcomes (Nam et al., 2014). Instead, research to date has largely focused on the accuracy of paramedic interpretation (Alalwan et al., 2023; Funder et al., 2020; Wyld et al., 2023)—without first establishing what baseline list of topics this accuracy is necessary for. Similar difficulties within the medical field led the American College of Cardiology and the American Heart Association to release a joint statement in 2001 listing the expected baseline competencies for all physicians, regardless of subsequent specialty (Kadish et al., 2001). Similarly, in 2020, a Delphi determined 23 "must know" electrocardiograph diagnoses expected of undergraduate medical students (Viljoen et al., 2020). Adopting such an approach in Australian and Aotearoa New Zealand paramedicine may pave the way for improved inter-tertiary consistency and patient safety.

LIMITATIONS

This research has several limitations:

- This study used electrocardiography as an exemplar topic. This is just one of numerous topics graduates will cover and cannot be used to reflect on the depth or consistency across other topics. It may be that the inconsistency demonstrated in electrocardiography is an outlier, with other topics demonstrating higher or lower heterogeneity.
- Curriculum variation cannot be assumed to match graduate paramedic capabilities. This study measured what graduates were taught, not what they are able to do.
- The study measured lecturer-reported curriculum content rather than independently verified curriculum documentation. Additionally, curriculum content was reported by a single representative from each university, and although participants were encouraged to review course materials, some misclassification remains possible.

- The survey taxonomy was constructed by consolidating teaching materials from three institutions and may not capture ECG topics taught exclusively at other universities; the five-stage development process and expert pretesting were designed to mitigate this risk, though some content gaps cannot be excluded.
- Readers may misinterpret the most popular topics as the most important. However, this project does not determine a "correct" list of topics to include.
- The internal validity of the Theory/Practiced/Assessed categorization is, beyond the pretesting, unproven. Teaching depth is best conceptualized as a spectrum, and this categorization, therefore, provides only a superficial gauge of differences in education. To improve the validity of this categorization, participants were provided with definitions of each category at survey commencement and free-text boxes to elaborate on their responses.
- Similarly, the teaching depth measurement is categorical, not scalar; consequently, it treats the difference between "assessed" and "practiced" as the same as "assessed" and "not taught", both receiving a binary 0 for overlap as they are different categories. These results may therefore overstate the true difference between universities.
- Participation remained voluntary and therefore some degree of self-selection bias cannot be excluded. Lecturers with stronger opinions regarding curriculum variation, standardization, or electrocardiography education may have been more likely to participate. Several factors reduce—but do not eliminate—this risk. Recruitment was undertaken from the entire target population rather than a sample, all eligible universities were approached, 94% consented to participate, and 78% ultimately returned completed surveys. Nevertheless, it remains possible that the curricula of non-participating institutions differ systematically from those represented here.
- These findings are specific to accredited undergraduate paramedicine programs in Australia and Aotearoa New Zealand, and may not be generalizable to other countries, postgraduate programs, or vocational education systems with different accreditation models.

RECOMMENDATIONS FOR PRACTICE

Three immediate uses follow from these findings. First, educators can benchmark local ECG coverage against the supplementary taxonomy to identify topics that are locally omitted or taught at unusually advanced depth; this should support curriculum review rather than ranking institutions. Second, ambulance services and other graduate employers can map induction and transition-to-practice education to topics that were inconsistently taught nationally, rather than assume uniform prior exposure; institutional aggregate data should not be used to infer an individual graduate's competence. Third, accreditation and professional bodies—including the Council of Paramedicine Deans, the Paramedicine Board, Te Kaunihera, employers, and educators—can convene a sector working group to determine whether a minimum set of ECG topics and expected educational depth is warranted.

RECOMMENDATIONS FOR RESEARCH

This research proposes two main future research recommendations. Firstly, this approach may be replicated across different subjects (such as cardiology more broadly,

and into other content such as trauma or respiratory). This could allow quantification of inconsistency at the course-wide, rather than subject-wide, level. Secondly, the results of this survey suggest it would be appropriate to develop a minimum curriculum for undergraduate electrocardiography. This may be suitably performed using a Delphi method, previously used for undergraduate medical electrocardiography (Viljoen et al., 2020)—with the panel of experts including university lecturers, but also employers from a range of industries who can inform the expected minimum standard of a registered paramedic. The 2025 UK report noted "a lack of consistency in feedback mechanisms between higher education institutions and ambulance services, which limited the ability to address any 12-lead ECG learning needs" (Health Services Safety Investigations Body, 2025, p. 5). Inclusion of a broad-based set of experts representing multiple practice environments may assist in addressing this in Australia and Aotearoa New Zealand. It is important to note that teaching "more" topics is not necessarily beneficial, as this may both overwhelm undergraduates and reduce teaching time, both of which lead to reduced comprehension (Sweller et al., 2019). Such a standardized list of topics should not be used to constrain or limit universities but instead ensure that all graduates are able to practice as autonomous paramedics safely.

CONCLUSION

This study aimed to quantify the proportion of predefined electrocardiography topics taught across programs, determine the depth at which topics are taught across programs, identify the degree of overlap and variation in content coverage between programs, and identify the opinions of lecturers on tertiary content variability. Electrocardiography education in undergraduate paramedicine programs in Australia and Aotearoa New Zealand is highly heterogeneous, with a mean SMC of 52% (range 1% to 90%). This includes topics with significant patient safety risks. In free-text, participants described it being "hard to know if we are teaching too much or not enough" and called for "a standardized minimally accepted practice level". These findings suggest that consideration should be given to whether a minimum curriculum framework would be beneficial.

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APPENDIX A: TAXONOMY OF ELECTROCARDIOLOGY CONTENT

Subject: Anatomy

Groups	Topics
Cardiac cell types	Conductive cells - pacemakers
	Contractile cells - myocytes
	Others - fibroblasts, endothelial cells, etc
Sinoatrial node	P cells
	T cells
Intra-atrial (Bachmann's) pathway	
Internodal pathways	Anterior tract
	Middle (Wenckebach's) pathway
	Posterior (Thorel's) pathway
Atrioventricular node	Regions - atrionodal, nodal, nodal-His
	Pathways - slow and fast
	Cells - ovoid and rod cells
Bundle of His	
Bundle branches	Left anterior fascicle
	Left intermediate (septal) fascicle
	Left posterior fascicle
	Right bundle branch
Purkinje fibers	
Accessory pathways	Bundle of Kent
	Bundle of James
	Atrio-Hisian tracts
	Mahaim Fibres

Subject: Physiology

Groups	Topics
The definition of electricity	
Movement of ions across cell membranes	Voltage gated channels
	Receptor gated channels
	Sodium-Potassium pump
	Calcium ATP pump
	Sodium-Calcium exchanger
	Sodium-Hydrogen exchanger
	Magnesium regulation of channels
	Potassium ATP channels (ischemic preconditioning)
Gap junction depolarization	
Cardiac myocyte action potential phases	Phases - polarization, depolarization, hyperpolarization, plateau
	Voltage levels of each phase
	Membrane movement in each phase
	Refractory periods - absolute and relative
	Afterdepolarizations - early (EAD) and delayed (DAD)
Pacemaker phases and action	Phase - 0, 3, 4
	Spontaneous depolarization
	HCN channels (pacemaker or funny current generators)
	Calcium channels
Autorhythmicity	SA node
	Escape autorhythmicity - atria, AV junction, purkinje
Excitation-contraction coupling	
Myocyte phases	Phase - 0-4

Groups	Topics
Autonomic nervous system effects	Chronotropy
	Inotropy
	Dromotropy
	Lusitropy
	Bathmotropy (excitability / irritability)

Subject: Terminology

Groups	Topics
Define and discuss 'electrodes'	Positive electrodes
	Negative electrodes
'Cables' / 'wires'	
'Leads' / 'views'	
'Isoelectric line' and 'deflections'	Isoelectric line
	Deflections
	Positive deflections
	Negative deflections
	Biphasic deflections
'Waves'	P
	Q
	R
	S
	T
	U
	Delta
	J (Osborne)
	Flutter
	F waves
	Epsilon
	Pacemaker spikes
Segments	PR
	ST
	TP
Intervals	PR
	RR
	QT
	QTc
Complexes	QRS
	Atrial pacemaker
	Ventricular pacemaker
	Sequential pacemakers

Subject: Electrode placement and electrocardiograph setup

Groups	Topics
Skin preparation	
Limb lead placement	Classic / Einthoven (distal limb) placement
	Mason-Likar (torso) placement
	Lund (thigh) placement
	Equidistant rule
	Effects of limb lead placement: diagnostic quality, tethering and noise
Precordial electrode placement	V1-V6
	Cabrera electrode placement
Right lead placement	V4R/V5R placement for right ventricle only
	Complete right-sided lead placement (V1R-V6R)

Groups	Topics
Posterior lead placement	V7-V9
Other leads	Fontaine leads
	Lewis leads
Precordial lead placement in females	Over vs under breast tissue
Pre-analysis	Right patient
	Usable tracing - no artifact
	Usable tracing - at least one P-QRS-T in each lead
	Usable tracing - isoelectric baseline
	Speed - 25mm/s
	Amplitude - 10mm = 1mV
	Frequency - calibration spikes
	Frequency - 1-30Hz
	Frequency - 0.05-40Hz
	Frequency - 0.05-150Hz
	Signs of correct placement - V6 / aVL same direction
	Signs of correct placement - aVR / II opposite direction
	Signs of correct placement - R wave progression
	Signs of correct placement - aVR mostly negative
	Signs of correct placement - I and V6 mostly positive

Subject: Leads

Groups	Topics
3-leads	Einthoven's triangle
	Bipolar leads I-III
6-leads	Goldberger's terminal
	Goldberger's terminal calculation
	Augmented limb leads / Unipolar aVL, aVR, aVF
12-leads	Wilson's common terminal
	Wilson's common terminal calculation
	Precordial leads V1-V6 printout format
	Cabrera printout format
	Contiguous leads
	Reciprocal leads
Right ventricular and/or posterior leads	V4R or V5R
	V7-V9

Subject: Rhythm analysis

Groups	Topics
Rate assessment	Reading the monitor
	Six second strip x 10
	Memorized scale of large boxes - 300/150/100/75/60
	Divide 300 by large boxes
	Divide 1500 by small boxes
Regularity	Regular
	Regularly irregular
	Irregularly irregular
P wave assessment	Upright
	Uniform
	Normal morphology
	P:QRS of 1:1
PR interval assessment	0.12 - 0.2

Groups	Topics
QRS assessment	<0.12 normal
	0.1-0.12 delayed conduction
	>0.12 wide

Subject: Sinus rhythm

Groups	Topics
Normal sinus rhythm	

Subject: Dysrhythmias

Groups	Topics
Ectopic sites and escape sites	Ectopic sites - PAC, PJC, PVC
	Escape sites - atrial, junctional, ventricular
Sinus dysrhythmias	P cell pathology
	Sinus dysrhythmia
	Sinus tachycardia
	Sinus bradycardia
	Sinus arrest
	Sick sinus syndrome generally
Sinus exit blocks	Sinus exit blocks generally
	T cell pathology
	1st degree
	2nd degree Type 1
	2nd degree Type 2
	3rd degree
Atrial dysrhythmias	Ectopic atrial rhythm
	Ectopic atrial bradycardia
	Ectopic atrial tachycardia & Paroxysmal atrial tachycardia
	Multifocal atrial rhythm (Wandering pacemaker)
	Multifocal atrial bradycardia
	Multifocal atrial tachycardia
	Atrial fibrillation - generally
	Atrial fibrillation - Multiple wavelets
	Atrial fibrillation - Focal area / automaticity
	Atrial fibrillation - 'Slow' AF
	Atrial fibrillation - Rapid ventricular response
	Atrial fibrillation - Ashman phenomenon (RBBB)
	Atrial flutter - generally
	Atrial flutter - Atrial re-entry circuit
	Atrial flutter - Conduction ratio
	Atrial flutter - Type 1 (Typical) - Anticlockwise
	Atrial flutter - Type 1 (Typical) - Clockwise
	Atrial flutter - Type 2 (Atypical)
Junctional dysrhythmias	Junctional escape rhythm
	Junctional bradycardia
	Accelerated junctional rhythm
	Junctional tachycardia

Groups	Topics
Re-entrant dysrhythmias	Accessory pathways
	Lown-Ganong-Levine syndrome
	AVRT - generally
	AVRT - WPW
	AVRT - Antidromic
	AVRT - Orthodromic
	AVNRT - generally
	AVNRT - slow-fast
	AVNRT - fast-slow
	AVNRT - slow-slow
	Outflow Tract Ventricular Arrhythmias - generally
	Outflow Tract Ventricular Arrhythmias - RVOTA
	Outflow Tract Ventricular Arrhythmias - ARVD
	Outflow Tract Ventricular Arrhythmias - LVOTA
AV nodal delays / blocks	1st degree
	2nd degree Type 1 / Mobitz 1 / Wenckebach
	2nd degree Type 2 / Mobitz 2
	2nd degree 2:1 undifferentiated
	2nd degree high grade
	3rd degree / dissociation
Bundle branch blocks	LBBB
	LAFB
	LPFB
	RBBB
	Bifascicular block
	Trifascicular block
	Masquerading block
Ventricular dysrhythmias	Asystole
	Ventricular standstill
	Agonal rhythm
	Idioventricular rhythm
	Accelerated idioventricular rhythm
	Ventricular tachycardia - generally
	Ventricular tachycardia - monomorphic
	Ventricular tachycardia - RVOT tachycardia
	Ventricular tachycardia - Fascicular tachycardia
	Ventricular tachycardia - Polymorphic
	Ventricular tachycardia - Torsades de pointes
	Ventricular fibrillation - generally
	Ventricular fibrillation - coarse
	Ventricular fibrillation - fine
Paced rhythms	Atrial pacemaker
	Ventricular pacemaker
	AV sequential pacemaker
	Failure to pace
	Failure to capture

Groups	Topics
Other dysrhythmias	Supraventricular tachycardias as a group
	VT vs SVT with aberrancy
	Wide complex tachycardia
	Narrow complex tachycardia
	Compensatory pauses
	Non-compensatory pauses
	Pulseless electrical activity generally
	Littman algorithm
	Pseudo-PEA
	R on T phenomenon

Subject: 12/15/16 lead analysis

Groups	Topics
Ischemia-injury-infarction paradigms? (e.g. STEMI / STEACS / OMI)	Q-wave vs. Non-Q-wave MI paradigm
	STEMI vs. NSTEMI MI paradigm
	STEACS vs. NSTEACS MI paradigm
	OMI vs. NOMI MI paradigm
Ischemia-injury-infarction ECG signs	Hyperacute T waves
	Hyperacute T waves - limb criteria
	Hyperacute T waves - precordial criteria
	Peaked T waves
	Flattened T waves
	T wave inversion
	T wave inversion - normal in III / aVR / V1 / pediatrics
	ST segment elevation
	ST segment depression - reciprocal change
	ST segment depression - subendocardial injury
	ST segment depression - up-sloping
	ST segment depression - down-sloping
	ST segment depression - horizontal
	ST segment slope - concave
	ST segment slope - convex
	Mechanism of ST segment changes - generally
	Mechanism of ST segment changes - Effect on pumps/exchangers
	Mechanism of ST segment changes - TP segment used as baseline
	Pathological Q waves generally
	Pathological Q waves - width criteria
	Pathological Q waves - depth criteria
Ischemia-injury-infarction ECG localization	Septal infarction
	Anterior infarction
	Anteroseptal infarction
	Lateral infarction
	Anterolateral infarction
	Wraparound infarction
	Posterior infarction
	Inferior infarction
	Inferolateral infarction
	RVMI
	LMCAO

Groups	Topics
Imposters / mimics	Left ventricular hypertrophy generally
	Left ventricular hypertrophy - Cornell criteria
	Left ventricular hypertrophy - Modified cornell
	Left ventricular hypertrophy - Sokolow-Lyon
	Left ventricular hypertrophy - Romhilt-Estes points system
	Ventricular rhythms
	Left bundle branch block
	Hyperkalemia
	Early repolarization
	Osbourne J waves
	Pericarditis
	Pericarditis - Spodick's sign
	Vasospasm (Prinzmetal's)
	Incorrect lead placement
	Paced rhythms
	Brugada - Sign Type 1
	Brugada - Sign Type 2
	Brugada - Sign Type 3
	Brugada - Syndrome
Equivalents	Reciprocal changes only visible - posterior or isolated RVMI
	LMCAO
	New left bundle
	New left bundle - Smith-modified Sgarbossa
	Wellens - Type A
	Wellens - Type B
	de Winter
	Aslanger
Chamber enlargement	Atrial chamber enlargement
	Ventricular chamber enlargement
Axis deviation	Axis deviation calculation
	Normal / Left / Right / Extreme regions
	Clinical significance
	Concordance

Subject: Miscellaneous topics

Groups	Topics
Miscellaneous	J point notching
	QT prolongation
	Long QT syndrome
	Pericardial effusion / tamponade on ECG
	Dextrocardia on ECG
	Transplantation on ECG
	Myocarditis on ECG
	Valvular patterns on ECG – generally
	Valvular patterns on ECG - Aortic stenosis
	Valvular patterns on ECG - Aortic regurgitation
	Valvular patterns on ECG - Mitral stenosis
	Valvular patterns on ECG - Mitral regurgitation
	Valvular patterns on ECG - Mitral prolapse
	Hypertrophies on ECG – generally
	Hypertrophies on ECG - Right atrial enlargement / P pulmonale
	Hypertrophies on ECG - Left atrial enlargement / P mitrale
	Hypertrophies on ECG - Dual atrial enlargement
	Hypertrophies on ECG - Right ventricular hypertrophy / strain
	Left ventricular aneurysm on ECG
	Dilated cardiomyopathy on ECG
	Hypertrophic cardiomyopathy on ECG
	Takotsubo cardiomyopathy on ECG
	Electrical alternans
Cerebral patterns	Raised intracranial pressure on an ECG
Pulmonary patterns	McGinn White sign (S1Q3T3)
	Pneumothorax on ECG
	Pulmonary hypertension on ECG
Metabolic patterns	Hypocalcemia ECG
	Hypercalcemia ECG
	Hypokalemia ECG
	Hyperkalemia ECG
	Hypomagnesemia ECG
	Hypermagnesemia ECG
Endocrine patterns	Hypothyroidism on ECG
	Hyperthyroidism & thyrotoxicosis on ECG
Toxicity patterns	Potassium efflux channel blocking drug toxicity
	Sodium channel blocker toxicity
	Sodium–potassium ATPase blocker toxicity
	Calcium channel blocker toxicity
	Beta blocker toxicity
Population variances	Indigenous
	Elderly
	Pediatrics
	Obstetrics
	Neonates

APPENDIX B: PRETEST SURVEY DESIGN FEEDBACK

Critical Care Paramedic & Paramedic Educator

- Email conversation, June 2024.
- 'Firstly, love it. This is amazing. Incredibly comprehensive. Well written. It might take a while, but it's really easy to move through. This was great. Well written. No other typos. And it all flowed well.. The second photo was just me clarifying something. Overall, there isn't anything else I would change. The survey flowed really well. I didn't find any other issues. I think it is a fantastic study and something that I have been preaching about at work. Particularly, since doing that ECG course. The variability in graduates' understanding of ECGs is unbelievable. I have grads who can barely differentiate sinus rhythm from AF, and the concept of a bundle branch block is completely foreign, let alone differentiating a STEMI mimic.'
- Sent a picture of the question on mechanism of ST segment elevation stating that it needed re-wording, with the comment 'The clarification was that the ST segment is measured from the TP interval.' This change was made.

Critical Care Paramedic

- Email conversation, June 2024.
- 'It's probably the limit that you'd want to do. I'll have a think but no real specific feedback apart from definitely not making it longer. I did it on the computer so can't speak for how it truly feels on a phone.'
- No further comments. No changes made.

Community Paramedic & Paramedic Educator

- Face to face conversation, 16/6/24.
- No specific feedback. No changes made.

University Lecturer who has taught electrocardiographs

- Telephone conversation, June 2024.
- Concern was that lecturers themselves may not know what the topics are, so suggested inserting definitions.
- No further comments. Insertion of definitions to be discussed with team.

University Lecturer who has taught electrocardiographs

- Email, June 2024.
- 'I have finally looked at the survey. I can see the effort and time this would have taken. It's a great initiative, and one very relevant to the accreditation processes Uni's are now going through. It reads well and is as brief as it can be.'
- No further comments. No changes made.

APPENDIX C: R CODE

Note – for a reader to perform the analysis themselves directly:

- Download the dataset from FigShare (https://figshare.com/articles/dataset/Dataset_xlsx/29387729)
- Merge the 11 sheets into one sheet
- Remove the headers (column A, rows 1-2) and summaries (rows 18-23)
- Run our code below

```
library(superheat)

library(readxl)

library(tidyverse)

library(hrbrthemes)

library(writexl)

library(e1071)

# Set up and preparation of data
  x<-Dataset|>as.matrix()
  storage.mode(x)<-"character"
  x[is.na(x)|trimws(x)==""]<-NA_character_
  n<-nrow(x); p<-ncol(x)
  unis<-paste0("University ",1:n)
  valid<-c("Not taught","Theory only","Practiced","Assessed")
  engaged<-c("Theory only","Practiced","Assessed")
  cat("Universities:",n,"\nTopics:",p,"\nResponses:",length(x),
      "\nNull responses:",sum(is.na(x)),
     paste0(" (",round(mean(is.na(x))*100,2),"%)\n"))
  unexpected<-setdiff(unique(na.omit(as.vector(x))),valid)
  if(length(unexpected)) warning("Unexpected values: ",paste(unexpected,collapse=", "))

# SMC (simple matching coefficient) calculations
  smc<-function(a,b){
    ok<-!is.na(a)&!is.na(b)
    if(!any(ok)) return(NA_real_)
    mean(a[ok]==b[ok])}
  smc_mat<-outer(1:n,1:n,Vectorize(function(i,j) smc(x[i,],x[j,])))
  dimnames(smc_mat)<-list(unis,unis)
  diag(smc_mat)<-NA_real_
  coef<-smc_mat[lower.tri(smc_mat)]
  stats<-tibble(
    Measure=c("Mean SMC","Median SMC","Q1","Q3","Minimum","Maximum","Skewness","Ex-
  cess kurtosis"),
    Result=c(mean(coef,na.rm=TRUE),median(coef,na.rm=TRUE),
             quantile(coef,.25,na.rm=TRUE),quantile(coef,.75,na.rm=TRUE),
             min(coef,na.rm=TRUE),max(coef,na.rm=TRUE),
             skewness(coef,na.rm=TRUE,type=3),kurtosis(coef,na.rm=TRUE,type=3)))
  print(stats)
```

```
# Comparing each university against each other
pairs<-expand_grid(University_1=1:n,University_2=1:n)|>
 filter(University_1<University_2)|>
 rowwise()|>
 mutate(
  Jointly_valid=sum(!is.na(x[University_1,])&!is.na(x[University_2,])),
  Matching=sum(x[University_1,!is.na(x[University_1,])&!is.na(x[University_2,])]==
          x[University_2,!is.na(x[University_1,])&!is.na(x[University_2,])]),
  SMC=Matching/Jointly_valid,
  SMC_percent=SMC*100)|>
 ungroup()|>
 arrange(desc(SMC))
print(slice_min(pairs,SMC,with_ties=TRUE))
print(slice_max(pairs,SMC,with_ties=TRUE))
# Saving the results
smc_pct<-ifelse(is.na(smc_mat),NA_character_,paste0(round(smc_mat*100),"%"))
dim(smc_pct)<-dim(smc_mat)
dimnames(smc_pct)<-dimnames(smc_mat)
write_xlsx(
 list(
  Matrix=cbind(University=unis,as.data.frame(smc_pct,check.names=FALSE)),
  Pairwise=pairs,
  Statistics=stats),
 "Pairwisematrix.xlsx")
# Classifying topics
topic_summary<-map_dfr(1:p,function(j){
 z<-na.omit(x[,j])
 u<-unique(z)
 same<-length(z)>0&&length(u)==1
 tibble(
  Topic=j,
  Valid=length(z),
  Null=n-length(z),
  All_same=same,
  All_same_value=if(same) u else NA_character_,
  All_engaged=length(z)>0&&all(z%in%engaged),
  Mixed=("Not taught"%in%z)&&any(z%in%engaged))})|>
 mutate(
  Classification=case_when(
   All_same&All_same_value=="Not taught"~
    "Consistent: not taught at any university",
   All_same&All_same_value%in%engaged~
    "Consistent: taught at all universities to the same level",
   !All_same&All_engaged~
    "Inconsistent: taught at all universities, to different levels",
   Mixed~
    "Inconsistent: taught at some universities, not at others",
   TRUE~"Unclassified"))
topic_counts<-topic_summary|>count(Classification,name="Value")
print(topic_counts)
```

```
write_xlsx(topic_summary,"Topics.xlsx")
get_n<-function(label){
  z<-topic_counts|>filter(Classification==label)|>pull(Value)
  ifelse(length(z),z,0)}
n_all_diff<-get_n("Inconsistent: taught at all universities, to different levels")
n_some<-get_n("Inconsistent: taught at some universities, not at others")
n_none<-get_n("Consistent: not taught at any university")
n_same<-get_n("Consistent: taught at all universities to the same level")
```

Figure 1

```
fig1_df<-tibble(
  Category=c(
    "Inconsistent: taught at all universities, to different levels",
    "Inconsistent: taught at some universities, not at others",
    "Consistent: not taught at any university",
    "Consistent: taught at all universities to the same level"),
  Value=c(n_all_diff,n_some,n_none,n_same)
)|>mutate(Category=paste0(Category," (n=",Value,")"),x="")
fig1<-ggplot(fig1_df,aes(x=x,y=Value,fill=Category))+
  geom_col(width=.5)+
  labs(title="Numbers of Topics by Consistency",x=NULL,y="Number of topics",fill=NULL)+
  scale_fill_manual(values=c("#002060","#51dff8","#489ff6","#eccfed"))+
  scale_y_continuous(breaks=c(0,50,100,150,200,250,300,350,p),
                     limits=c(0,p),expand=c(0,0))+
  theme_minimal()+
  theme(axis.text.x=element_blank(),axis.ticks.x=element_blank())
print(fig1)
ggsave("Figure 1.jpeg",fig1,width=10,height=6,dpi=1200)
```

Figure 3

```
dimnames(smc_mat)<-list(as.character(1:n),as.character(1:n))
pal<-colorRampPalette(c("white","#51dff8","#002060"))(100)
jpeg("Figure 3.jpeg",width=11,height=9,units="in",res=1200)
superheat(
  smc_mat,
  scale=FALSE,
  heat.pal=pal,
  heat.lim=c(0,1),
  heat.na.col="#002060",
  grid.hline=FALSE,
  grid.vline=FALSE,
  title="Figure 3: Heatmap of Simple Matching Coefficients",
  title.size=6,
  title.alignment="center",
  legend.breaks=c(0,1),
  legend.num.ticks=5)
dev.off()
```

Figure 4

```
set.seed(42)
fig4<-tibble(Coefficient=coef,Name="SMC")|>
  ggplot(aes(Name,Coefficient))+
```

```
  geom_violin(trim=FALSE,fill="#51dff8",alpha=.4,color=NA)+
  geom_jitter(color="#002060",size=1.5,alpha=.8,width=.15)+
  geom_boxplot(width=.15,outlier.shape=NA,alpha=.4,fill="#002060")+
  coord_flip()+
  scale_y_continuous(limits=c(0,1),breaks=c(0,.25,.5,.75,1),
                     labels=scales::percent_format(accuracy=1),
                     name="Simple Matching Coefficient")+
  theme_ipsum()+
  theme(
    legend.position="none",
    plot.title=element_text(size=18,face="plain",hjust=.5),
    axis.title.y=element_blank(),
    axis.text.y=element_blank(),
    axis.ticks.y=element_blank() )+
  ggtitle("Figure 4: Distribution of Simple Matching Coefficients Across University Pairs")
ggsave("Figure 4.jpeg",fig4,width=10,height=6,dpi=600)
```

Figure 5

```
depths<-as.data.frame(x)|>
  mutate(University=unis)|>
  pivot_longer(-University,names_to="Topic",values_to="Value")|>
  filter(Value%in%valid)|>
  count(University,Value,name="Count")|>
  complete(University=unis,Value=valid,fill=list(Count=0))|>
  mutate(
    University=factor(University,levels=unis),
    Value=factor(Value,levels=c("Assessed","Practiced","Theory only","Not taught")))
fig5<-ggplot(depths,aes(University,Count,fill=Value))+
  geom_col()+
  labs(title="Figure 5: Teaching Depth by University",x="University",
       y="Number of topics",fill="Category")+
  scale_fill_manual(values=c(
    "Assessed"="#002060",
    "Practiced"="#489ff6",
    "Theory only"="#51dff8",
    "Not taught"="#eccfed"))+
  scale_y_continuous(limits=c(0,p),breaks=c(0,100,200,300,p),expand=c(0,0))+
  theme_minimal()+
  theme(axis.text.x=element_text(angle=45,hjust=1))
ggsave("Figure_5.jpeg",fig5,width=10,height=6,dpi=600)
```

Summing uni totals

```
university_totals<-depths|>
  pivot_wider(names_from=Value,values_from=Count,values_fill=0)|>
  mutate(
    Non_null=Assessed+Practiced+`Theory only`+`Not taught`,
    Null=p-Non_null)
write_xlsx(university_totals,"University_category_totals.xlsx")
```

Sensitivity analysis excluding university 7

```
x7<-x[-7,,drop=FALSE]
m7<-outer(1:nrow(x7),1:nrow(x7),Vectorize(function(i,j) smc(x7[i,],x7[j,])))
```

```
diag(m7)<-NA_real_
c7<-m7[lower.tri(m7)]
sensitivity<-tibble(
  Measure=c("Mean SMC","Median SMC","Q1","Q3","Minimum","Maximum","Skewness","Ex-
cess kurtosis"),
  Result=c(mean(c7,na.rm=TRUE),median(c7,na.rm=TRUE),
           quantile(c7,.25,na.rm=TRUE),quantile(c7,.75,na.rm=TRUE),
           min(c7,na.rm=TRUE),max(c7,na.rm=TRUE),
           skewness(c7,na.rm=TRUE,type=3),kurtosis(c7,na.rm=TRUE,type=3)))
print(sensitivity)
write_xlsx(sensitivity,"University_7_sensitivity_analysis.xlsx")
conflict<-apply(x7,2,function(z){
  z<-na.omit(z)
  "Assessed"%in%z&&"Not taught"%in%z})
conflict_topics<-tibble(Topic=1:p,Maximum_conflict=conflict)|>
  filter(Maximum_conflict)
cat("Maximum-conflict topics excluding University 7:",
    nrow(conflict_topics),"of",p,
    paste0(" (",round(nrow(conflict_topics)/p*100,1),"%)\n"))
write_xlsx(conflict_topics,"Maximum_conflict_topics_excluding_University_7.xlsx")
```

Summary

```
summary_output<-tibble(
  Measure=c(
    "Universities","Topics","Total responses","Null responses","Null responses (%)",
    "Consistently not taught","Consistently taught at same depth",
    "Taught at all universities to different depths",
    "Taught at some universities and not others",
    "Pairwise comparisons","Mean SMC (%)","Median SMC (%)","Q1 (%)","Q3 (%)",
    "Minimum SMC (%)","Maximum SMC (%)","Skewness","Excess kurtosis",
    "Maximum-conflict topics excluding University 7",
    "Maximum-conflict topics excluding University 7 (%)",
    "Sensitivity mean SMC (%)","Sensitivity median SMC (%)",
    "Sensitivity minimum SMC (%)","Sensitivity maximum SMC (%)"),
  Result=c(
    n,p,length(x),sum(is.na(x)),mean(is.na(x))*100,
    n_none,n_same,n_all_diff,n_some,length(coef),
    mean(coef,na.rm=TRUE)*100,median(coef,na.rm=TRUE)*100,
    quantile(coef,.25,na.rm=TRUE)*100,quantile(coef,.75,na.rm=TRUE)*100,
    min(coef,na.rm=TRUE)*100,max(coef,na.rm=TRUE)*100,
    skewness(coef,na.rm=TRUE,type=3),kurtosis(coef,na.rm=TRUE,type=3),
    nrow(conflict_topics),nrow(conflict_topics)/p*100,
    mean(c7,na.rm=TRUE)*100,median(c7,na.rm=TRUE)*100,
    min(c7,na.rm=TRUE)*100,max(c7,na.rm=TRUE)*100))
write_xlsx(summary_output,"Analysis_summary.xlsx")
cat("Analysis complete.\n")
```

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RESEARCH REPORTS

THE PAIRED LEARNER MODEL FOR PARAMEDIC PRACTICUM: A TWO-YEAR MIXED METHODS IMPLEMENTATION STUDY IN A CANADIAN PARAMEDIC PROGRAM

Efrem M. Violato, PhD*[1]; Benjamin Rauschning, RRT[2]; Sidney L. Newman[1,3]; Jasmine M. Kayanja[1,3]; Cameron A. Rimstad[1,4]; Jakki Lea, ACP[2]

Author Affiliations: 1. School of Health and Life Sciences, Centre for Advanced Medical Simulation, Northern Alberta Institute of Technology, Edmonton, Alberta, Canada; 2. Advanced Care Paramedic Program, Northern Alberta Institute of Technology, Edmonton, Alberta, Canada; 3. University of Alberta, Edmonton, Alberta, Canada; 4. MacEwan University, Edmonton, Alberta, Canada.

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**Corresponding Author:*
efremv@nait.ca

ABSTRACT

Introduction: To address training constraints related to the need to train more paramedics and concurrent limited placement opportunities, as well as enhance learning, the Paired Learner Model (PLM), informed by social and constructivist learning theories, pairs two students with two preceptors in a single ambulance. The PLM maintains a 1:1 preceptor–student ratio. Throughout the practicum an ambulance placement will have two students and two preceptors who complete the practicum together.

Methods: A two-year (2023–2024) quasi-experimental, convergent parallel mixed-methods design compared the PLM with traditional practicum. Data forms were integrated through "narrative weaving" to evaluate learning outcomes, operational feasibility, and participant perceptions.

Results: The study included 33 participants: 12 PLM students, 9 single learners, 10 preceptors, and 2 program coordinators. All groups reported high preparedness for practice and positive overall practicum experiences. Preceptors unanimously reported that students were safe to practice and competent to care for a loved one. Student experiences aligned with social and constructivist learning theories. Preceptors noted reduced workload and increased capacity for student placements. Post-practicum, 9/10 preceptors thought the PLM should continue. No safety issues were reported.

Conclusion: The PLM is a feasible, educationally sound, effective, and acceptable alternative to the traditional practicum model. Interpersonal dynamics challenges can be addressed through planning and preparation. Findings support continued implementation and further multi-institutional research, with a larger sample size beyond the present single-site study, to explore long-term outcomes and refine best practices.

INTRODUCTION

Clinical practicum is a cornerstone of paramedic education (Batt et al., 2024). Diverse models exist, but practicum typically involves a student placed with a paramedicine service in a one-

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to-one learner-preceptor pairing (J. Brown et al., 2025; Hanna et al., 2021). The preceptor provides education, guidance, mentorship, and assessment of the student to prepare them for entry to practice (J. Brown et al., 2025; Hanna et al., 2021). Despite its ubiquity, the traditional practicum model has minimal supporting evidence (Carroll et al., 2023; Hanna et al., 2021; Worsfold et al., 2024). System, organizational, and human factors have strained this model, limiting placement opportunities, creating variable experiences, and potentially affecting training quality (J. Brown et al., 2025; Casey, 2023; Hobbs et al., 2025; National Union of Public and General Employees (NUPGE), n.d.; Newton et al., 2024; Sheahan et al., 2025). A major source of this strain is growing student enrollment to address workforce shortages concurrent with those same workforce shortages, high patient loads, unhealthy culture, practitioner burnout, and attrition that impacts the number of clinical sites available to place students (Bellefontaine, 2023; Casey, 2023; Herttuainen & Nordquist, 2023; Newton et al., 2024). These pressures have created a need to explore alternative models to enhance educational quality and support workforce sustainability (J. Brown et al., 2025). A potential alternative model is the Paired Learner Model (PLM), where two students are paired with two preceptors per ambulance.

In other health disciplines, various instructor-to-student ratios are used (Markowski et al., 2021). In medicine, ratios up to 1:5 are considered optimal for teaching rounds (Kumar et al., 2024; Rong et al., 2022), and the Accreditation Council for Graduate Medical Education mandates a 1:3 faculty-to-resident ratio (ACGME, 2025). In nursing, instructor-to-student ratios typically range from 1:6-10 (Nursing Clinicals, 2023), and Occupational Therapy and Physiotherapy may use 1:2 ratios to foster peer learning and collaboration (College of Physiotherapists of Alberta, 2021; Crouch et al., 2002). In paramedicine, PLMs have been used sporadically when placements are limited; however, evidence remains anecdotal.

The PLM is supported by social cognitive theory, which emphasizes observational learning, where learners benefit from observing peers in real-time scenarios, receiving immediate, contextualized feedback (Bandura, 1977). Constructivist theory also supports the PLM through peer-to-peer collaborative learning through sharing, support, and explanation (T. Brown, 2023).

To gather initial evidence for the feasibility, acceptability, and potential effectiveness of the PLM, a two-year implementation study was conducted (2023–2024) to understand if the PLM:

- Can be practically implemented.
- Provides a safe and supportive learning environment for students.
- Affects preparedness and professional competency.
- Could increase practicum placement capacity.
- Affects preceptor workload, fatigue, and feelings of burnout.

METHODS

Study Design & Materials

A quasi-experimental convergent parallel mixed-method design was used, including surveys and semi-structured interviews. For each group, questionnaires and interviews were developed de novo with paramedic program administration and independently reviewed by staff with precepting experience (see Supplemental Material). Pre-practicum

surveys examined expectations for practicum, perceived preparedness, interpersonal familiarity, and prior experience. Post-practicum surveys mirrored and expanded on the pre-practicum survey. Semi-structured interviews explored survey constructs in greater depth. Ethics approval was obtained from the Northern Alberta Institute of Technology Research Ethics Board (REB#:2023-10–Amended), all participants provided consent to have their data included in the study at each point of data collection. Four groups were included:

- Intervention: students in the PLM.
- Comparison: students in the 1:1 practicum.
- Preceptor: preceptors in the PLM.
- Practicum coordinators: academic staff responsible for coordinating practicums.

PLM Setting and Context

The PLM was implemented with Primary Care Paramedic (PCP) students. In Canada, PCPs provide context-specific basic life support and patient care in rural/remote, urban/suburban, industrial, air ambulance, and military settings. Controlled or delegated acts in the PCP competency profile include intravenous cannulation and administration of certain medications. PCPs constitute the largest group of paramedics in Canada (Canadian Organization of Paramedic Regulators, 2023; National Occupational Competency Profile for Paramedics, 2011). PCP programs are typically one year or shorter and require an Emergency Medical Responder/Medical First Responder and Basic Life Support CPR certification. Practicum is typically a 4–6 week placement with an urban or rural ambulance service. Students are assigned to a preceptor with primary mentorship and assessment responsibility.

In the PLM, each student is paired with a preceptor, as during a single practicum. However, in the PLM, two student–preceptor dyads are assigned to the same ambulance, resulting in two students and two preceptors working together throughout the practicum. The pairing remains consistent across the placement, barring unforeseen operational circumstances. Before the practicum begins, program coordinators meet with preceptors to discuss the PLM. Coordinators and preceptors discuss considerations around the structure and expectations of the PLM, including how during a call students may take active or observational roles or share a call. Students could run a call solo, together, with a preceptor, or with a preceptor stepping to take over if necessary. Preceptors retain professional discretion to teach and support students as they typically would. The practicum retains standard outcomes, with each student being required to individually attain all competencies to complete the practicum. Each student receives a final assessment from their assigned preceptors.

Sample

Each year, based on the number of placements the program could secure, eight students participated in the PLM. Program coordinators presented information about the PLM and its purpose to all students in the cohort preparing for practicum. Because student participation in the PLM was voluntary, inclusion was on a first to volunteer basis. All students and preceptors in the PLM were invited to participate in the study. To serve as a comparison group to the PLM, eight of the thirty-two students completing a traditional practicum were targeted for participation in the study. Two practicum coordinators were

invited for interviews. The Principal Investigator (PI) sent recruitment emails to students and preceptors. Eligibility criteria included enrollment as a PCP student or precepting in the PLM.

PROCEDURES

Pre-practicum, participants received an email link to the survey hosted on Qualtrics (Qualtrics, 2024). Consent was affirmed before the survey through an online consent form. Post-practicum, participants were contacted to complete the survey (Qualtrics) and semi-structured interviews (video or telephone). Consent was reaffirmed electronically (survey) and verbally (interview) before data collection. The PI conducted interviews which lasted 45-60 minutes. Interviews were audio-recorded, transcribed verbatim, and anonymized (Figure 1).

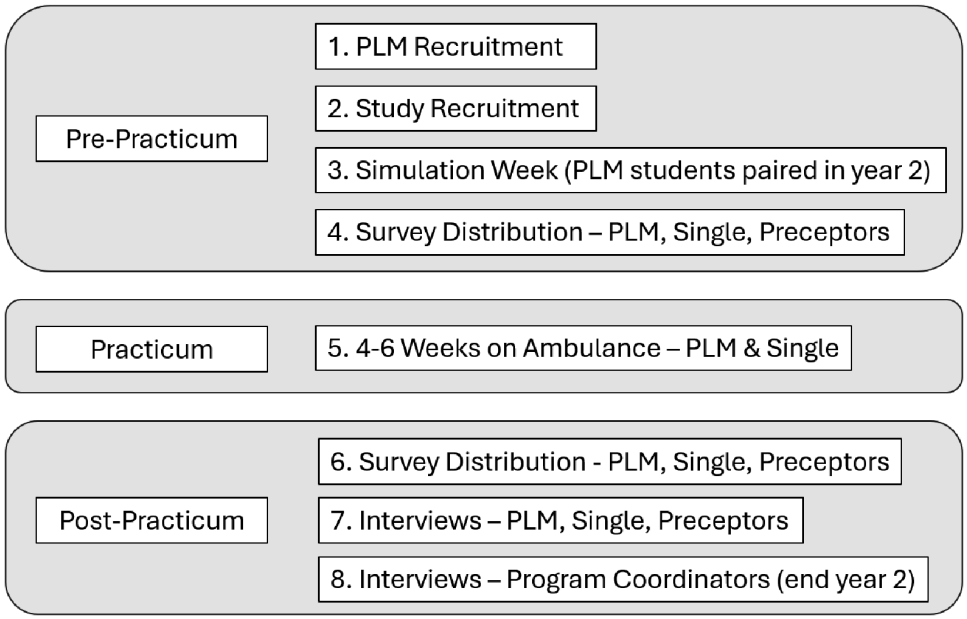


Figure 1. Study flow diagram.

Data Analysis

Closed-ended items and count data were analyzed using frequentist, descriptive, and inferential statistics (Mann-Whitney U or Chi-Square). Qualitative analysis used a qualitative descriptive approach to provide a comprehensive summary of events that stays close to participants' experiences rather than interpret, explain, or derive themes (Sandelowski, 2000; Villamin et al., 2025). Three authors (SN, JK, CN) independently reviewed transcripts to identify events and experiences before comparing findings. During the comparative process, any differences were re-reviewed and discussed until consensus was attained. If consensus was not attained, a fourth author (EV) reviewed the findings to resolve the discordance. Common experiences were used to produce a description of the practicum.

Data Mixing

To provide comprehensive insight into the PLM, quantitative and qualitative data were integrated through a process of "narrative weaving," where quantitative and qualitative findings are linked and embedded and presented jointly on a concept-by-concept basis in a single report (Fetters et al., 2013). To achieve integration, throughout the analysis, quantitative and qualitative data were read and interpreted together in an iterative process with the authors continuously examining where linkages existed between the two data forms and how each data form supported the interpretation of the other. This process was selected to utilize the large amount of rich data and present a complete, coherent, and interpretable understanding of the PLM.

RESULTS

Sample

Responses to data forms varied across years. As recruitment, follow-up, and compensation were identical each year, participation appeared to vary randomly. Across the study, 68 surveys or interviews were completed (Table 1). Some participants enrolled in the study did not participate in all stages of data collection, including some who completed post-practicum measures but did not complete pre-practicum measures; not all participants responded to all survey items. All preceptors had prior experience (Mean=15.3 years; Median=14.5 years; Range=13–19 years), having precepted 2–10 students, and had completed preceptor training.

		No. of Responses		
Data Form	**Group**	**2023**	**2024**	**Total**
Pre-Survey	Paired	5	2	7
	Single	0	9	9
	Preceptor	4	1	5
Total		9	12	21
Post-Survey	Paired	7	5	12
	Single	1	6	7
	Preceptor	7	3	10
Total		15	14	29
Interview	Paired	4	3	7
	Single	0	6	6
	Preceptor	1	2	3
	Coordinator	0	2	2
Total		5	13	18
Total Complete Data Forms Across All Measures		**29**	**39**	**68**

Table 1. Participant response rate by data form, year, and total.

Pre-Practicum

Program coordinators reported that practicum sites' interest in the PLM was mixed, with several sites initially skeptical and critical primarily due to a preconception that the PLM was one preceptor supervising two students, and concern about ambulance overcrowding. Site visits were conducted with preceptors and service leadership to discuss the PLM and address concerns.

In the paired and single learner groups, most students (10/13) did not know their preceptor at all; the remainder knew the preceptor to some extent. No responding preceptors knew the student, although they knew their colleague very or extremely well. Students ranged from not knowing their peer at all to knowing them extremely well. Peer pairings were split between self-chosen (45.5%) and assigned (54.5%) pairs. Overall, students (n=14) felt ready to practice. PLM learners reported feeling slightly to very well prepared.

Preceptors were prepared for the PLM. Preceptors felt burnout occasionally, though not related to precepting. Preceptors thought the PLM could help reduce burnout and workload while helping train more students.

Logistics

Preceptors reported no major logistical issues due to the PLM. As challenges such as ambulance space or scene management arose, they were dealt with but did not impede care or learning and the standard workflow was maintained. Post-practicum, 6/10 preceptors agreed that PLM reduced workload as there was an extra person to assign tasks to and help with activities, so preceptors could focus on other tasks.

Thirteen students reported completing four or five weeks of practicum, with three PLM students completing six weeks. Reported call volume per shift was similar (p=.54, d = .31 [95%CI = -.64 – 1.24]) between paired (mean = 5.17, SD = 2.08, median = 5) and single learners (mean = 4.57, SD = 1.62, Median = 4) and preceptors (mean = 4.3, SD = 1.42, Median = 4). Most students in both groups, and all preceptors, felt the call volume was low and could be a challenge for learning, but was adequate for preparedness. Preceptors reflected that there were fewer practice opportunities, “fewer reps,” and worked with the student to prioritize competencies to ensure attainment. Students in both groups reported challenges meeting competencies. Students in the PLM tended to attribute the challenge to being with a peer, though all students obtained the required competencies. Preceptors described a mix of independent and shared competency demonstrations: one student might perform a competency, and at other times, a call was shared.

Experience

All students completed their practicums. No difference (p = 0.59, φ = .19) was found in self-perceived preparedness or overall practicum experience (p = .149, φ = .33) post-practicum, between PLM and single learners. For paired learners, 75% reported being "very/extremely well" prepared, while for single learners, 67% reported being "very/extremely well" prepared. Preceptors rated readiness for practice for their student and their partner's student from "moderate" to "extremely well" prepared. A positive experience was reported by all single learners (7/7) and most paired learners (9/12). One preceptor thought the PLM was worse than a single practicum for the student and preceptor.

Except for cases of personal conflict, the coordinators reported that students indicated that the PLM was a great experience and enjoyed the emphasis on teamwork with a peer: "All the pairs that went out this last year all said that they really, really appreciated the opportunity to be part of the paired practicum." Coordinators indicated that preceptors and sites liked the PLM because it prepared students for the interpersonal and teamwork aspects of paramedicine. Post-practicum, 9/10 preceptors did not believe the PLM affected burnout, as burnout is complex, personal, and for the current sample, generally not related to precepting. Eight of ten preceptors believed the PLM could help train more students, by requiring fewer ambulances to place students on. Nine of ten preceptors thought the PLM should continue.

Interpersonal

Most students in both practicums reported strong rapport with their preceptors and rated their preceptors as excellent. Reciprocally, preceptors described positive connections with students. In the PLM, two students and one preceptor had a mutually negative relationship and rated each other as poor or terrible. The preceptor described the PLM

as a very negative experience and felt that the PLM amplified the students' "inadequate approach". No overt or escalated conflict was reported, and patient care was not affected.

In the PLM, students experienced non-adversarial, positive competition and pressure to perform that was not instigated by preceptors: "I felt like there was a very healthy level of like pressure but also support." Students who knew each other before the PLM more often discussed beneficial pressure compared to learners who did not know their peer.

Strong negative experiences arose in one dyad due to many interpersonal challenges: "She stole my practicum." Coordinators identified the biggest PLM challenge as student interpersonal issues. Coordinators discussed the importance of anticipating who will work well together and placing those students together. During the second year, PLM pairings were placed together during a pre-practicum simulation week completed by all students. The simulation week consisted of four to five high-fidelity simulations each day that were designed to prepare students for practicum. PLM students completed the simulations together, while other students rotated through different groupings and pairings as usual. Students reported that being paired during simulation helped with familiarization and was beneficial preparation for practicing together: "…we knew how each other acted, we knew how each other worked, and we knew cues that we could pick up on each other."

Teaching and Learning

Students in both practicums experienced a structured and planned learning environment with clear expectations. Students and preceptors acknowledged the dynamic contingencies of paramedic practice: "So I did feel it was as structured as a paramedic practicum can be." Prior preceptor experience reduced the need for specific planning for the PLM with preceptors using a self-discovery or guided learning approach. Students thought preceptors provided appropriate support, with the level of intervention calibrated to call difficulty. Preceptors discussed how expectations for student performance, responsibility, and autonomy increased with time and ability, and autonomy and responsibility could differ between students depending on ability.

PLM students found that certain calls were difficult to include two students in, though students also reported that the break from providing care and standing back and observing how someone else practiced was beneficial and supported their learning; providing a different perspective and giving space to think about how to act. Seeing different practice approaches modelled was beneficial: "Half my role was standing back when we were together, so I felt like, definitely at some points, yes, it was beneficial to see how another person might approach a situation." PLM students supported each other by reviewing calls, sharing knowledge, studying together, and asking each other questions about calls: "I loved having a paired practicum for sure, like emotionally and learning wise I think it really helped me." Preceptors noted that it was good for the students to have someone to talk to and study with. Students in the single practicum thought observation and peer support were the primary appeal of the PLM.

Participants discussed occasionally leaning on their partner for assistance during calls. While generally seen as positive, in the negative PLM experience, the participant intentionally distanced themselves during calls so that their peer would not rely on them.

Paired learners felt that their partner was ready for practice; only one indicated their peer was not at all prepared and indicated they learned nothing from their peer.

Both groups reported high comfort approaching preceptors for help, including the peer's preceptor in the PLM. In the PLM, both preceptors supported both students with the roles for learning, supervision, discussion, and feedback being highly fluid. Preceptors indicated that group debriefing was most common, though preceptors were conscientious about how feedback was provided; negative or focused feedback was delivered in isolation, instead of in pairs. Students' preference for one-to-one debriefing or a group setting was contingent on the situation, interpersonal relationships, and personal preference. In both groups, students and preceptors indicated that post-call constructive conversations and criticism occurred, with the primary obstacle being fatigue.

No patient safety concerns were reported; all preceptors trusted their students and their partner's students to treat a loved one. All students (n = 12) thought that their preceptor and their peers' preceptor provided a safe or very safe practice and learning environment, and that their peer could practice safely.

Support

Preceptors and students in both groups felt that the school provided appropriate support during practicum, though PLM students wanted more explanation of the PLM before beginning practicum. Students in the single practicum frequently discussed a desire for more psychological and mental health support; however, no PLM students mentioned a desire for more support. Preceptors noticed having someone to talk with who was sharing the same experience benefited students.

Program coordinators identified that sites participating in the PLM in the first year viewed the PLM as successful and advocated for the PLM "…all of the sites seemed eager to do it again, who had participated in the first round." Preceptors' enjoyment of the PLM was important for sites' willingness to continue participation.

DISCUSSION

Based on the results from multiple integrated data forms, the PLM was practically feasible; call volume was similar to the single practicum, students felt ready for practice and preceptors agreed, all students completed practicum, and no patient safety concerns were reported. Both groups achieved the required competencies to complete practicum, and overall, students and preceptors viewed the PLM positively, with added learning opportunities.

Student Experience

Reports of effective peer-to-peer and observational learning in the PLM parallel findings in other professions where collaborative clinical education models have been associated with improved learning outcomes, increased student confidence, and reduced preceptor workload (Markowski et al., 2021).

Interpersonal dynamics and team formation are critical for model success (Markowski et al., 2021). The negative experiences that arose resulted from interpersonal differences, peer familiarity, and assignment method (self-selected vs. assigned), rather than being

structural to the PLM. These challenges are not unique to the PLM; the same issues and negative experiences are reported in 1:1 placements (J. Brown et al., 2025; Hobbs et al., 2025). Modifications through conscientious and intentional pairing after the first year largely addressed interpersonal issues. Careful consideration of interpersonal dynamics, classroom instructor input, simulation before practicum, team-building activities, and, if possible, peer self-selection can enhance peer matching to optimize collaborative learning and pre-emptively identify interpersonal issues. Additionally, the PLM may be viewed as an advanced or alternative learning model for students who are appropriately suited and prepared.

Further support and utility of the PLM model is found in the behavioral and cognitive manifestations of social learning and constructivist theory observed during the PLM. Although PLM students may get "fewer reps," opportunities to observe and learn from more people can present richer learning opportunities than a single placement. More diverse learning opportunities can strengthen skills, deepen knowledge, and refine mental models/cognitive schemas of paramedic practice. The PLM was described as beneficial educationally and emotionally with students being able to learn with and from each other by reviewing calls, studying together, and supporting each other throughout the practicum. Students also engaged in constructing their learning by seeking help and asking questions of preceptors, and through collaborative call debriefing and discussions. These results align with the preceptors planned self-discovery/guided learning approach. Positive, healthy competition can also provide motivation to improve performance.

In the single practicum, students are members of the team, but an inherent status differential exists between preceptor and student. The PLM may provide more opportunities for teamwork, team-based care, and interprofessional collaboration than the standard practicum, potentially enhancing readiness for entry to practice. PLM students discussed the emotional and personal social support of having a peer; social support and a shared experience are another potential benefit of the PLM that could moderate the need for external mental health support.

Preceptor Experience

The reported benefit and lack of burden for PLM preceptors, with no reports of feelings of burnout, differ from other samples (Hobbs et al., 2025). The extra student reduced workload and made workflows more efficient, providing operational advantages over a single practicum which may enhance the precepting experience. To contribute to a positive PLM experience, support, preparation, and training from the school placing students are necessary. The PLM can also be an impetus for preceptor training.

Future Research

Multi-institute study and longitudinal outcomes of the PLM can help identify if performance differences exist between paired vs. traditional practicum after entry to practice, particularly for patient care quality and collaborative practice competency. A patient-oriented research approach during the PLM would be valuable, though in the context of pre-hospital emergency care, this could be difficult or inappropriate. Further investigation of peer-to-peer and observational learning should examine how learning occurs

and objective outcomes. Potential differences in the desire for support and mental health between the PLM and traditional practicum can be investigated.

LIMITATIONS

Three primary limitations existed.

- Convenience sampling with a relatively small sample size from a single institution and region limits generalizability and power/interpretability of inferential statistics. Alignment of outcomes with the underlying theory indicates that similar results could be replicated in other settings.
- Reliance on self-report measures and qualitative feedback, potentially introduces response bias. Mixed methods and alignment across data types support the validity of the findings, but objective assessment and following learners into practice would strengthen inferences.
- Participation was inconsistent throughout both years, with some participants inconsistently completing data forms. During the first year, no students from the comparison group participated.

CONCLUSION

The PLM is feasible, maintains essential educational outcomes, and provides social and observational learning and operational benefits. Compared with the traditional practicum, the PLM showed no apparent disadvantages, with preceptors endorsing student competence by unanimously trusting students to care for a loved one. Although interpersonal dynamics can be challenging, overall, this initial PLM implementation was a successful positive experience for learners and preceptors. All groups showed near-unanimous support for continuing the PLM, and the model warrants further study and refinement with larger scale research and evaluation beyond this single site implementation study.

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REVIEWS

CHEMICAL RIOT CONTROL AGENTS: A NARRATIVE REVIEW FOR PREHOSPITAL PROVIDERS

Frederick B. Rogers, MD, MS, MA, FACS*[1]; Nicholas J. Larson, BA, NREMT[1]; David J. Dries, MD, MSE, FACS[1]; Benoit Blondeau, MD, MBA, FACS[1]; James E. Kenny, MD, MS[1]

Author Affiliations: 1. Department of Surgery, Regions Hospital, Saint Paul, MN, USA.

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**Corresponding Author:* frederick.b.rogers@healthpartners.com

ABSTRACT

Background: There may be situations in which a prehospital provider may encounter a scene where certain chemical riot control agents (RCA) may be employed as a mode to produce rapid sensory and respiratory impairment during crowd-control operations. Recent years has seen an increase in utilization of RCAs by law enforcement agencies meaning prehospital providers may be called to respond to these situations, underscoring the importance of proper training and a fundamental understanding of the various RCAs that may be employed, their effect on biological systems, and how to protect themselves from secondary exposure in the field. In this review we cover the most common RCAs, their mechanism of action, biological effects and how to protect themselves in the field.

Methods: The PubMed and Cochrane Reviews databases were queried for articles related to protests, riot control agents, emergency medical services, and medical care from inception to January 2026. A narrative review methodology was employed to facilitate a broad overview of the most common RCA used today, their mechanism of action and effects on biologic systems, their potential to exacerbate pre-existing medical illnesses, and specifically how the prehospital providers should protect themselves during contact with these substances.

Results: The most common RCAs are chlorabenzilidinemalononitrile (CS), chloroacetophenone (CN), dibenzyl [b, F]- [1, 4] – oxazepane (CR), and oleoresin capsicum (OC) referred to in aggregate as 'tear gas' (CS, CN, CR) or 'pepper spray' (OC). Ocular, dermal, respiratory, and GI symptoms are usually mild and self-limited, although more severe reactions can occur. Treatment is focused on the safety of the prehospital provider first and foremost, and then extrication of the patient to a safe area free of exposure to any RCA. Ocular and skin effects are treated with copious irrigation with water, while respiratory and GI effects are treated symptomatically. Most symptoms should subside in 15 to 30 minutes, although persistent symptoms may indicate more serious complications. There is no known antidote to RCA exposure.

INTRODUCTION

The right to protest is inextricably woven into the fabric of a democratic society. The unfortunate reality is that situations may occur where force is deployed, increasing the risk of injury to all present. In this situation, certain chemicals riot control agents (RCA]) may be employed as a mode to produce rapid sensory and respiratory impairment during crowd-control operations. The increased frequency of use of RCAs in recent years means

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a prehospital provider may be called to respond in these situations, highlighting the importance of having a fundamental understanding of the types of RCAs, how they affect biological systems, the potential to exacerbate pre-existing illnesses, and how prehospital providers can protect themselves from being secondarily affected through exposure in the field. In this review we will present some of the most common RCA used today, their mechanism of action and effects on biologic systems, their potential to exacerbate pre-existing medical illnesses, and specifically how the prehospital providers should protect themselves during contact with these substances.

METHODS

A narrative, rather than systematic, review was chosen to allow for broad interpretation of the literature as it currently stands related to RCAs and prehospital providers. This was chosen in accordance with methodological considerations described in the International Journal of Clinical Practice (Motevalli, 2025). The PubMed and Cochrane Review databases were queried for all peer reviewed publications related to protests, riot control agents, emergency medical services, and medical care from inception to January 2026. "Riot control agents," "tear gas," "EMS," "prehospital," and "riot" were utilized as keywords with relevant articles being chosen for inclusion by senior authors (FR, DD). Citation matching from relevant articles was conducted to ensure seminal studies/reports were not missed.

Most Commonly Employed RCAs

Table 1 depicts the most commonly employed RCAs (Hotchkins & Clapham, 2024). When discussing these RCAs, they are frequently referred to by their unique 1 to 3 letter military designation. These include dibenz [b, f] – [1,4] oxazepane (CR), chloroacetophenone-one (CN), chlorabenzilidinemalononitrile (CS) and oleoresin capsicum (OC) (Frey et al., 2022). The use of RCAs by law enforcement has been legal since 1975 when Gerald Ford signed executive order 11850, permitting the use of RCAs in selected defensive situations such as controlling rioting prisoners and other potential noncombat situations (Executive Orders, 2016). RCAs are often referred to as 'tear gas' and function by causing irritation to the eyes, mouth, airway, lungs and skin, rendering the recipient temporarily unable to function (CDC, 2024). The designation tear 'gas' is a misnomer as these compounds exist as liquids or solids (e.g. CN and CS are released in the air as fine droplets or particles). Primarily, exposure is through contact with the skin, eyes, or by inhalation, with effects seen within seconds and lasting around 15 to 30 minutes (CDC, 2024). It should be noted there is no antidote for these agents, despite the common myth that pouring milk, particularly in the eyes, can counteract the effects of a RCA ("Preparing for, Protecting Against, and Treating Tear Gas and Other Chemical Irritant Exposure," n.d.).

CN is a white crystalline solid which was popular as a RCA in the 1950s, however due to potential toxicity it has largely been replaced with CR and CS, with CS being the most widely used RCA in the world (Bessac et al., 2009; Frey et al., 2022; Olajos & Salem, 2001). That said, CN is still used in certain instances and is often labeled as 'mace' spray (2-Chloroacetophenone, 2000). CS, discovered in 1928, and is a solid white powder at room temperature (Blain, 2003). It has less deleterious health effects than CN and has largely replaced this agent as a RCA. CR is a yellow solid synthesized in 1962 and, like

CS, is a commonly used RCA (Smith & Greaves, 2002). Pepper spray, also known as OC, gains its name from capsaicin, the active ingredient derived from chili peppers responsible for its irritating effects (Vaca et al., 1996). The concentration of OC in pepper spray ranges from 1 to 15% with the most common concentration of OC identified in RCAs being 2%. Bear spray, often considered to be more potent, has the same concentration of capsaicinoid as pepper spray, but delivers a wider and longer-range cloud to deter a charging animal (Wilder et al., 2023). A common mechanism of RCA deployment is through mixing CS with CR or CN along with a pyrotechnic compound that releases a fog of aerosolized solids upon detonation (Henry, 1998). RCAs may also be deployed as 'pepper balls', launched projectiles that release a RCA upon impact (Hu et al., 1989).

Biological Effects of RCAs

Table 2 shows the clinical effects of RCAs on various organ systems. The primary organ systems affected are the eyes (lacrimation [crying], burning, blepharospasm [abnormal eye twitching], and inflammation), respiratory (rhinorrhea, sneezing, cough, dyspnea,

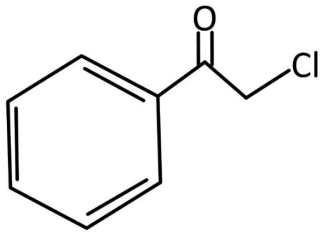
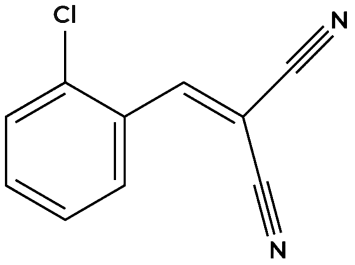
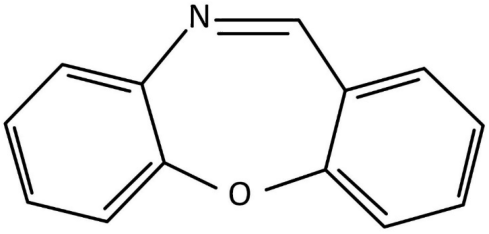
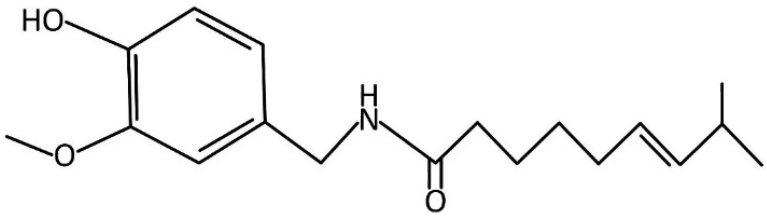
Military Designation	Chemical Name	Common Name	Chemical Structure
CN	2-Chloroacetophenone	Tear Gas	
CS	2- Chlorobenzylidinemalononitrile	Tear Gas	
CR	Dibenzo[b, f] [1,4] Oxazepine	Tear Gas	
OC*	8-Methyl-N-vanillyl-trans-6-nonenamide (capsaicin)	Pepper Spray (Mace)	

Table 1. Common riot control agents (Hotchkins & Clapham, 2024).
*Note: *OC is not a discrete chemical but a mixture of naturally occurring capsaicin compounds. The chemical structure of capsaicin is provided*

and pulmonary edema), gastrointestinal (nausea, vomiting, and gastrointestinal discomfort particularly if ingested) and skin (erythema, blisters, chemical burns, and contact dermatitis). It should be noted that unique to OC is loss of the blink reflex (Olajos & Salem, 2001). Most of the effects of RCA are mild and last only a few minutes. A recent review of 9261 RCA injuries found that 74.3% of injuries were minor and transient, 17% moderate (either unexpected injuries or lasting longer than expected) and 8.7% severe (requiring health care system intervention) (Haar et al., 2017). Of severe injuries identified there were 2 deaths; 58 individuals suffered permanent disabilities including loss of limbs, persistent vegetative state, and permanent loss of sight (Haar et al., 2017). Another report describes an infant who required Extracorporeal Membrane Oxygenation (ECMO) due to an accidental exposure to pepper spray from his mother's keychain (Billmire et al., 1996). The potential for more serious reactions from RCA exposure are primarily related to duration of exposure, higher concentration of exposure in an enclosed space, and underlying conditions such as a history cardiac or respiratory disease (Aktan, 2013; Karagama et al., 2003). Prehospital providers should be aware of the risk of prolonged or repeated exposure in the line of duty when caring for multiple patients in a mass casualty incident (MCI).

Organ System	Biological Effect
Central Nervous System	Fear Anxiety Headache
Ocular	Pain Lacrimation Blepharospasm Conjunctival Inflammation
Respiratory	Rhinorrhea Sneezing Cough Dyspnea Bronchoconstriction
Gastrointestinal	Nausea Vomiting Abdominal Pain
Skin	Pain Erythema Edema Blisters Contact Dermatitis

Table 2. Common effects of RCAs on various organ systems (Morrone et al., 2005; Oaks et al., 1960; Schep et al., 2015; Sommer & Wilkinson, 1999; Torgrimson-Ojerio et al., 2021).

Secondary effects of RCAs may be related to blunt or penetrating traumatic injury from the delivery vehicle. A review of 10 patients with penetrating head trauma from tear gas canisters in Iraq reported a 100% mortality rate, while a 2013 article from Turkey reports on ten protesters suffering from numerous lacerations, all of whom lost eyes, with one even requiring orchidectomy from the use of tear gas canisters by police (Aktan, 2013). Other reports have documented skull fractures, facial injuries, subarachnoid hemorrhage, and even burns from the pyroelectric chemicals in the delivery process (Agrawal et al., 2009; El Zahran et al., 2021).

Logistics of Prehospital Management in Situations of RCA Exposure

Provider Safety

The foremost priority of any prehospital provider called to the scene where RCAs may potentially be used is to ensure that the prehospital team does not become secondarily injured. This includes delaying arrival until the scene is safe from violence and utilization of proper personal protective equipment, preferably with a full-face National Institutes for Occupational Safety and Health (NIOSH) rated air purifying respirator that

has a specific CN/CS/OC chemical filter (Chemical, Biological, Radiological, and Nuclear (CBRN) Respiratory Protection Handbook., 2018).

Patient Safety

Removal of the patient from the contaminated area should occur as the first step in the primary survey. If inside, extrication to an outdoor space will allow for fresh air to dilute lingering RCAs in the respiratory tract. Aerosolized RCAs tend to accumulate in dependent areas (e.g. close to the ground). Unconscious patients should be lifted as high as possible to limit continued exposure (Schep et al., 2015). Likewise, ambulances or helicopters should be parked at the highest elevation areas available to limit provider exposure. Heavily contaminated patients should have their clothes removed. In situations of dermal or ocular exposure, irrigation with copious amounts of saline is recommended for decontamination. If saline is not readily available, prehospital tap water is an acceptable alternative. Most CBRNE (Chemical Biological Radiological Nuclear and Explosives) can be decontaminated with tap water (Coleman et al., 2019). If symptoms persist for more than a few minutes, rapid transport to a hospital is necessary to prevent/mitigate long-term effects. Prehospital assessment after exposure to a RCA should prioritize identification of the RCA used, symptoms of those exposed, assessment of lung sounds, and documentation of other traumatic injuries (Region 11 Chicago EMS System, 2024).

It is preferable with any CBRNE that the patient be decontaminated prior to transport to the hospital. Transporting an incompletely decontaminated patient risks producing symptoms in the transport crew with potential serious consequences. It also risks contaminating the vehicle, rendering that vehicle out of service until decontamination can be done. If decontamination is unable to be done in the field, after arrival at a hospital patients exposed to RCAs will require decontamination. In a MCI patients will need to be triaged, and a designated area of the hospital will need to be "dirtied" to house patients prior to decontamination. Depending on the scale of the event, prehospital providers may be called upon to monitor patients waiting for decontamination for acute decompensation, with particular care given to those at a high-risk of RCA injury (the very young, the very old, the immunocompromised, and those with asthma or other respiratory diseases). Irrigation with large volumes of water or saline is the preferred method of decontamination; many other compounds have been tried with none showing demonstrable superiority to water/saline (Olajos & Salem, 2001).

Organ System Effects and Treatment

Ocular

The ocular system is one of the primary targets of an RCA. Symptoms include pain, blepharospasm, photophobia, conjunctivitis with both conjunctival and scleral injection, periorbital edema, and profuse lacrimation (Schep et al., 2015). Symptoms typically commence within 20 to 60 seconds of exposure. Usually, ocular effects are mild and self-limited but more severe injuries such as corneal abrasion, inflammation of the middle layer of the eye (uveitis), bleeding in the eye (hyphemia), cataracts, and optic neuropathy with loss of sight have been reported (Oaks et al., 1960). Treatment for ocular exposure is copious irrigation with water/saline until symptoms begin to subside. Contact lenses should be removed before eye irrigation. The recommended length of time for irrigation varies from 10-20 minutes. Any persistent symptoms after irrigation should prompt transfer

to a hospital for a full ophthalmologic exam. If Morgan lenses are available in the field, they can be employed to facilitate ocular irrigation. A Morgan Lens is a specialized soft plastic contact lens device that is attached to IV tubing that is utilized for continuous hands-free ocular irrigation. It is commonly used in many Emergency Departments.

Respiratory

Effects on the respiratory system include stinging or burning in the nose, chest pain and tightness, dyspnea, cough, sneezing, and breath holding (Schep et al., 2015). Copious rhinorrhea ensues and contaminated saliva may create gastrointestinal (GI) symptoms. Persistent coughing may lead to vomiting. Treatment initially is to remove the patient from the contaminated area into fresh air, with most symptoms subsiding within 15 to 30 minutes. Patients who do not respond quickly should have oxygen saturation monitoring and supplemental oxygen provided. More severe respiratory reactions have been reported including bronchospasm, laryngospasm, coughing up blood (hemoptysis), chemical pneumonitis, pulmonary edema and asphyxia thus it is imperative that prehospital personnel have the resources available for advanced airway techniques (Billmire et al., 1996; Vaca et al., 1996).

Central Nervous System

The most common central nervous system (CNS) symptoms are panic and agitation. Other potential CNS symptoms are fever, syncope, headache and dizziness (Schep et al., 2015). Removal from the RCA area to fresh air may calm an anxious patient. However, severe CNS symptoms such as loss of consciousness should prompt ALS interventions.

Skin

The most common dermal effect after RCA is a tingling or burning sensation. Prolonged or severe RCA exposure can lead to erythema, blistering, and contact dermatitis (Schep et al., 2015). Dermal effects of RCA are often more common with handheld spray products as the solvents may contribute to cutaneous complications ranging in severity from mild erythema to delayed onset acute generalized exanthematous pustulosis (a rare severe skin reaction characterized by rapid widespread onset of small nonfollicular pustules on reddened skin often accompanied by fever and high white count) (Morrone et al., 2005; Sommer & Wilkinson, 1999). Beyond the chemical irritants, RCA delivery devices have been reported to cause burns from contact with the hot metal canisters or by the flame generated from the pyrotechnic launching agents used.

Treatment of dermal effects commences by removal of contaminated clothing and flushing the skin area with cool copious flowing water to remove the contamination and settle the burning sensation. Saline can be used for irrigation in those areas where vesicles have been formed (Schep et al., 2015). Other decontaminating agents such as baby shampoo (Winslow et al., 2006), sodium bicarbonate (Weigernd, 1969), diphoterine (Viala et al., 2005) (chelating agent) or vegetable oil (Jones et al., 1987) have been reported as alternative to water, though there is little evidence of improved benefit.

Gastrointestinal (GI)

The primary GI effects of RCAs come from swallowing crystals; GI effects include nausea, vomiting and GI discomfort. Delayed GI and even menstrual changes have been

reported (Torgrimson-Ojerio et al., 2021). Prehospital providers must always be vigilant to suspect blunt traumatic abdominal injuries in anyone complaining of abdominal pain in situations where RCAs have been employed as blunt impact from tear gas canisters or traumatic injury from violent altercations are possible.

ADDITIONAL CONSIDERATIONS

When dealing with victims of RCAs, many times it is in the context of large protests where there may be a large number of victims, akin to an MCI. Additionally, the use of RCAs at densely populated events runs the risk of bystander injury from panic and subsequent trampling. In October of 2022 at Kanjuruhan Stadium in Indonesia, over 320 people were injured with 135 deaths after fans rushed the field in response to their team losing the soccer match. Law Enforcement arrived on scene and utilized RCAs in an attempt to obtain control of the crowd triggering mass panic, crush injuries and suffocation. The use of RCA is widely attributed as one of the key factors in triggering the stampede ("Major Stadium Disasters over Recent Decades," 2024; Wiyono et al., 2023). It is important for providers to be vigilant and look beyond potential chemical injuries for physical trauma and dangerous situations that may unfold as a result of RCA deployment.

In situations where RCAs are used during/results in an MCI, prehospital providers should utilize established incident command systems, and field triage guidelines designated by an experienced triage officer. Many prehospital triage guidelines exist to classify patients by need for intervention and likelihood of success, with the highest priority patients being those with critical, but treatable injuries (Prehospital Trauma Life Support, 2023). It is worth repeating that the primary goal of a prehospital provider is the safety of themselves and their team. It is imperative they begin to provide care only when it is safe and avoid inserting themselves into an unstable or metastable situation.

LIMITATIONS OF THIS REVIEW

This review did not follow prespecified inclusion and exclusion criteria for chosen studies. While this facilitated a broad overview of the current state of the literature, it may have introduced bias into the findings. This manuscript is meant to serve as an educational adjunct for providers who may be unfamiliar with practicing in settings where RCAs may be employed. The suggestions made in this manuscript are those of the authors based on the cited literature and are not a substitute for good clinical judgment or experience.

SUMMARY

The most common RCAs are CS, CN, CR, and OC referred to in aggregate as 'tear gas' (CS, CN, CR) or 'pepper spray' (OC). Ocular, dermal, respiratory, and GI symptoms are usually mild and self-limited, although more severe reactions can occur. Treatment is focused on the safety of the prehospital provider first and foremost, and then extrication of the patient to a safe area free of exposure to any RCA. Ocular and skin effects are treated with copious irrigation with water, while respiratory and GI effects are treated symptomatically. Most symptoms should subside in 15 to 30 minutes, although persistent symptoms may indicate more serious complications. There is no known antidote to RCA exposure.

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REVIEWS

HOW DO NEWLY QUALIFIED PARAMEDICS EXPERIENCE THE TRANSITION TO AUTONOMOUS PRACTICE, AND WHAT ROLE DO FORMAL SUPPORT STRUCTURES PLAY IN THIS TRANSITION? A SCOPING REVIEW

Iain Darby, DipHE, BA(Hons), PGCert*[1]; Ursula Rolfe, PhD, MPhil, BSc(Hons)[1]; Edwin van Teijlingen[1]; Scott Devenish, PhD, MaVEdT, BNur[2]

Author Affiliations: 1. Bournemouth University, Poole, Dorset, UK; 2. Griffith University, Southport, QLD, Australia.

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**Corresponding Author:* idarby@bournemouth.ac.uk

ABSTRACT

The objective of this scoping review is to understand the extent and type of evidence in relation to graduate paramedic transition into autonomous practice and what role formal support structures such as preceptorship play in this process.

Healthcare graduates experience a range of challenges on transition into the work-place. Many organizations provide formal support to mitigate some of these chal-lenges. This review sought to understand the evidence related to the 2 concepts.

A PCC framework was used to frame the review question, inclusion criteria being English language, peer reviewed studies which included paramedics with less than 3 years' experience post qualification, the years 1997-2026 were chosen for inclusion also.

EBSCO, Web of Science and Scopus databases were searched on 30th May 2026. English language and the years 1997-2026 applied as limiters. Titles and abstracts were used for the first stage of screening before remaining studies were scrutinized using inclusion / exclusion criteria applied independently by 2 reviewers. Data was extracted independently by 2 reviewers before being written up by the first author.

5 themes were identified: professional socialization, emotional burden, relational perspective, theory-practice gap, and workplace culture. Graduates experienced a range of challenges, barriers, and facilitators during transition. Formal support structures were noted to form part of this.

Formal support structures such as preceptorship can help graduates overcome challenges faced in their transition into autonomous practice. Further research is required from a graduate's perspective to design robust preceptorship systems

INTRODUCTION

On completion of their higher education, graduate paramedics enter an important stage in their career making the transition from student to autonomous practitioner and several studies have highlighted that this can be a turbulent time (Phillips and Trenoweth, 2023; Carver and Lazarsfeld-Jensen, 2018; Kennedy et al., 2015).

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From an ambulance perspective, paramedics in several countries are expected to work through a period of formal support and guidance, called preceptorship or internship, which can vary slightly in terms of regulatory requirements from one ambulance service to another.

The National Health Service (NHS), in the United Kingdom (UK), suggests that "Preceptorship is a period of structured support provided at key moments of early career transition", providing a personalized program of support both through university and multi-professional activity (NHS England, 2023). Additionally, the UK regulator for paramedics, The Health and Care Professions Council (HCPC, 2023) and professional body, The Royal College of Paramedics, highlight principles for preceptorship involving organizational culture, quality oversight, and preceptee empowerment.

In Australia and New Zealand, graduate paramedics are generally required to undertake a 12-month period of internship, supported by an experienced preceptor or mentor (Hanna et al., 2021). While the Australian Jurisdictional ambulance services and some private employers offer a range of internship models, which are often dependent on state or territory requirements (Bosley and Daley, 2023; Queensland Ambulance, 2023; Tasmanian Government, 2023; Australian Capital Territory, 2025). Similarly, The Paramedic Association of Canada (PAC, 2024) suggests a minimum period of consolidation post-graduation, lasting at least 12 months. The model in the United States of America (USA) is far more varied, with each state jurisdiction taking responsibility for any orientation requirements. In the Republic of Ireland, paramedics undertake an internship as part of the second year of a three- year degree. However, they are supervised throughout this internship year and so the notion of autonomous practice is misleading in this instance and less comparable to UK or Australian models where the degree journey is complete prior to commencement of full employment (O'Grady et al. 2026). Conversely, other countries such as South Africa do not offer a structured support period to graduate paramedics on commencement of employment (Mosiane et al., 2025; Lombard et al. 2026).

Several studies have highlighted challenges in transition to autonomous practice (Kennedy et al., 2015; Hanna et al. 2021) while research into specific paramedic preceptorship programs is limited. Nursing literature, which is more prevalent, describes several challenges including newly graduated nurses reporting feelings of apprehension and a lack of confidence (Harrison et al., 2020) with Jeffrey et al. (2023) suggesting that difficulties with unfamiliar professional responsibilities and role ambiguity also play a part in these initial challenges. Walker and Norris (2020) highlighted the value of a preceptorship program in general nursing, suggesting the importance of a structured program and the need to support new staff in making autonomous clinical decisions, including one-to-one support from trusted preceptors (Ratta, 2016; DeGrande et al., 2018).

CONTEXT FOR SEARCH

Existing reviews were identified by Kennedy et al. (2015) and Hanna et al. (2021). Kennedy et al. (2015) examined broad transition challenges of graduate paramedics but without the additional focus on the place of structured, formalized support. Hanna et al. review (2021) similarly looked at broad challenges of graduates and considered the value of preceptorship in their journey; however, this was considered more from the preceptor's viewpoint rather than the preceptee which is how this review differs.

REVIEW QUESTION

Preliminary searches were conducted in conjunction with university library teams plus websites such as Google Scholar to help generate appropriate search terms. Additionally, authors ensured that terms were viewed from an international perspective, from this, the review question was formulated: How do newly qualified paramedics experience the transition to autonomous practice, and what role do formal support structures play in this transition?"

METHODS

A scoping review methodology was chosen to understand the breadth of knowledge on this subject and this review was conducted using the Joanna Briggs Institute (JBI) PCC framework of 'population,' 'concept,' and 'context' (Hadie, 2024). The review was designed to comply with PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyzes extension for Scoping Reviews) reporting guidelines (Tricco et al., 2018).

Relevant search terms and synonyms were generated as listed in Table 1.

PCC	Search Terms
Population	'Newly qualified paramedic* OR "NQP" OR "paramedic*" OR graduate paramedic* OR novice paramedic* OR intern paramedic* OR "ambulance officer*" OR "primary care paramedic*" OR "advanced care paramedic*" OR ambulance clinician*"
Concept	transition* OR "transition to practice" OR "transition to work" OR "autonomous practice" OR preceptor* OR preceptorship OR mentor* OR support* OR orientat* OR intern* OR supervision OR "OR "professional identity"
Context	ambulance service* OR "emergency medical service*" OR EMS OR prehospital OR pre-hospital OR "out-of-hospital" OR ambulance OR emergency care

Table 1. Search terms.

Table 2 lists the inclusion and exclusion criteria which were set prior to searches being carried out to reduce any risk of bias and ensure that any findings were robust (Swift and Wampold, 2018).

Inclusion / Exclusion Criteria

The criteria of primary sources ensured that only original research was included and secondary research such as existing literature reviews were excluded. To encompass as much of the literature as is reasonable but to allow for papers to focus on true newly qualified experiences, it was decided early in the review to consider less than three years as 'newly qualified'. NHS Employers (2017) use two years to define this period of being newly qualified in paramedics and there are examples across other health professional literature ranging from below 12 months to 5 years (Davidson and Darracott, 2024; Lao et al., 2022; Harvey-Lloyd et al., 2019; Chesterton et al., 2023). It was felt that defining 'newly qualified' as less than three years would allow for the balance required.

The timeframe 1997-May 2026 was applied to searches to reflect the timeframe during which paramedics have undertaken higher education for qualification as a paramedic. It was noted that the first paramedic degrees were taught in Australia in 1994 meaning the first graduates transitioned into practice from 1997 (Lord, 2003), with similar HE programs commencing in the UK in 1999 (Carney, 1999).

Studies involving only students were excluded as the focus of the research question is graduate paramedics who have completed a period of higher education to gain their

status as qualified. Additionally, studies were excluded if they contained any profession other than paramedics.

Literature that considered newly qualified staff who graduated during the COVID-19 pandemic was also discounted as it was a period of upheaval in health services worldwide and did not represent a 'standard' transition into autonomous practice (HCPC, 2020). Finally, the focus of this scoping review is the experiences of preceptees / newly qualified staff and therefore any papers focusing on the experiences and perceptions of preceptors were discounted.

This review sought to consider worldwide literature to fully appraise and understand graduate paramedic's transition to autonomous practice and any support structures such as preceptorship. Therefore, no geographical limits were placed on the search process. However, inclusion criteria sought to ensure the focus was experiences of graduates post higher education which had the natural effect of limiting countries which would be included.

Papers from peer reviewed journals were chosen to ensure a minimum standard of quality (Aveyard, 2023) and only papers in the English language were selected due to limited resources for translation. Finally, gray literature was not included as it brings several challenges, including time and resource availability plus a lack of accessibility and full peer review (Brown, 2025).

Inclusion	Exclusion
• Primary Sources Only • Studies of 'newly qualified' paramedics, defined as <3 yrs practice post university qualification • Publications in English • Peer review publications • Year of publication 1997-May 2026	• Studies only involving students • Studies which do not involve paramedics • Non-English language papers • Non-peer-reviewed: e.g. government reports, service evaluations • Studies that consider transition to practice during COVID- 19 • Studies on 'preceptors' not 'preceptees' • Gray literature

Table 2. Inclusion / exclusion criteria.

Final searches were undertaken on 30th May 2026 with a university supported search engine (EBSCO) being used, this platform provided a combined search of the following databases: Academic Search Ultimate, APA PsycArticles, APA PsycInfo, APA PsycInfo, CINAHL Ultimate, Communication Source, ebook Collection, ebook Open Access, Education Source, ERIC, Library Information Science and Technology Abstracts, MEDLINE Complete, SocINDEX, and SPORT Discus. On the same day, separate but similar searches were conducted on Scopus and World of Science

Study Selection

Identified citations were collated into Endnote (Version 21.3 Clarivate Analytics, PA, USA) and duplicates removed. This left 34,012 papers which were screened by the first author against the review question using the title and abstract (Figure 1). This left 12 papers for an assessment of eligibility against the inclusion / exclusion criteria. This was undertaken initially by the first author before distribution for further assessment by other reviewers (co-authors), this was undertaken blinded to the first reviewer's opinion. Disagreements between reviewers at each stage of the selection process were resolved

through discussion. Eight papers were removed at this stage with one further paper identified through citation searching (Aveyard, 2023).

Data Extraction

A bespoke data extraction tool was used, based on existing JBI templates (Aromataris et al., 2024; Peters et al., 2020). Early versions of this tool were tested on included papers which were then modified iteratively to produce the final data extraction tool. The data extracted includes specific details about the location, participants, methodology, transition experiences, barriers, and facilitators plus any specific findings regarding graduate experiences, challenges, facilitators, and formalized support for graduates. Data were extracted from papers included in the scoping review by two independent reviewers. Any disagreements that arose between the reviewers were resolved through discussion or by a third reviewer, if required.

Study	Reason for Exclusion
Hoberg et al., 2018	Not paramedics, study on nurses in Swedish ambulance service.
Lombard et al., 2026	Participants had more than three years' experience.
O'Grady et al., 2026	Participants were students as degree had not been completed.
O'Brien et al., 2014	Not primary research
Sinclair et al., 2025	Participants commenced employment during COVID-19 pandemic
Herttuainen et al., 2023	Included nurses; not reported separately by professional groups.
Malgas et al., 2023	Participants had more than three years' experience.
Lazarsfeld- Jensen, 2014	Participants had more than three years' experience.

Table 3. Excluded papers with reason.

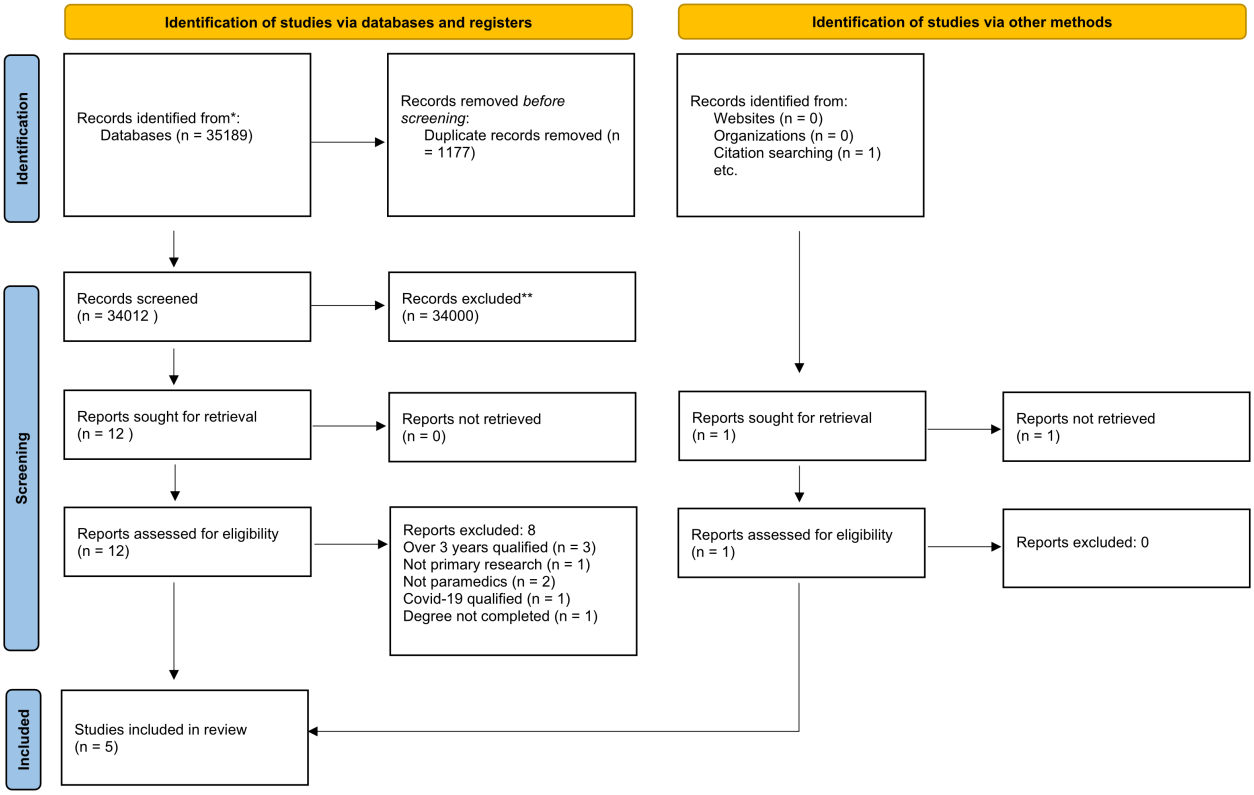


Figure 1. Study selection.

Data Analysis

Papers were analyzed using qualitative content analysis as described by Braun and Clarke (2006). This tool was selected as it allowed for codes and themes to be drawn out via an inductive approach (Braun and Clarke, 2006). Additionally, this is a tool which focuses on qualitative studies which the bulk of this review considered. There is a small element of quantitative results in one paper (Phillips and Trenoweth, 2023), but this paper still had an overarching qualitative focus.

RESULTS

Five papers were included in the final analysis with five themes summarized in data extraction table (Appendix 1): (1) professional socialization; (2) emotional burden; (3) relational perspective; (4) theory-practice gap; and (5) workplace culture.

Professional Socialization

Professional Socialization was a factor for graduate paramedics as they transitioned into autonomous practice with Devenish et al. (2016), suggesting different periods of socialization as a graduate develops a professional identity, adapts to their new role and ultimately become 'accepted' members of their profession. Devenish et al. (2016) suggested graduates became pessimistic, often disparaging ambulance management to adopt existing cultures and 'fit in'. These stages of development are especially relevant to graduates in the 'post formal socialization' stage, which Devenish et al. (2016) noted, was especially related to graduates in their internship year.

This is further supported by Filstad and McManus (2011) who pointed out that graduates must not 'rock the boat' and gradually understand the culture, referred to as 'learning the code' (Filstad and McManus, 2011). They go on to highlight how participants felt that becoming part of the family was a useful metaphor for this process, stating that 'once you accepted as a family member, then you become socialized' (Filstad and McManus, 2011), Thompson (2015) noted the challenge of learning to deal with other ambulance staff appropriately.

The notion of identity plays a key part in this process. Phillips and Trenoweth (2023) found that graduates' identity often related to a 'catalyst event', a life-threatening injury or illness as a process which graduates must go through to feel 'accepted'. Participants felt that catalyst events helped them to gain approval and respect of their colleagues, thus facilitating the socialization process, also described as a 'rite of passage' (Devenish et al., 2016).

Emotional Burden

The emotional burden in a graduate's transition to autonomous practice is characterized by emotional and psychological challenges, self-doubt, fear of making mistakes, which is often underpinned by an increase in personal responsibility (Phillips and Trenoweth, 2023; Mosiane et al. 2025; Thompson, 2015). Mosiane et al. (2025) described 'increased pressure and responsibility' and the 'weight' of being the sole decision maker on scene. Thompson (2015) alluded to this, as graduates describe how the 'safety net' of being a student was removed and describing concerns about professional registration, leading to 'defensive practice'. Phillips and Trenoweth (2023) described feelings of emotional vul-

nerability and self-doubt, especially in participants who had not yet attended a 'catalyst event'. Devenish et al. (2016) highlighted this increased responsibility and related lack of confidence as notable factors in the post internship phase of socialization.

Graduates also report personal emotional turbulence, related to the types of incidents attended. Filstad and McManus (2011) noted participants must cope with their emotions in this newly qualified phase due to the 'extreme and horrific events' they can experience. Mosiane et al. (2025) describe the emotional impact from traumatic events was a key finding in their study, with this often leading to thoughts of leaving the paramedic profession.

Relational Perspective

The positive and negative aspects of relationships with colleagues were noted by this review. Supportive relationships with experienced colleagues, mentors, and peers were found as important in the transition period with graduates relying on an experienced colleague during the first period of autonomous practice (Thompson, 2015). Devenish et al. (2016) found graduates were influenced by their mentors and this underpinned much of their approach to their new role with debriefing with work partners was also of value. Filstad and McManus (2011) surmised the importance of 'being in contact with the right person' in terms of learning a new role, arguing that it's important for newly qualified paramedics to know how to access experienced staff and how to make use of those contacts.

Phillips and Trenoweth (2023) highlighted the positive aspects of being part of a social group, which was highlighted in their quantitative data, with social support enhancing self-perceived resilience scores, implying a better transition into their autonomous role. Conversely, Phillips and Trenoweth (2023) also found negative experiences in terms of not being accepted into the group, with some not prepared to alter core values to seek acceptance or describing increased stress levels in terms of proving themselves to colleagues as well as navigating their new role.

Filstad and McManus (2011) noted these elements of power in their findings and pointed out that power relations can 'deny as well as facilitate necessary access to colleagues'. Devenish et al. (2016) are more explicit in highlighting how participants experienced tension between being university graduates and vocational trained paramedics plus there were challenges in navigating relationships between themselves as senior clinicians working with older colleagues who had a lower scope of practice.

Theory-Practice Gap

The theory-practice gap can be summarized as a disconnect between what is taught/learned in university and the practical realities of clinical work, but also in terms on tacit knowledge and cultures of the workplace.

Thompson (2015) stressed this was a big factor in the eyes of graduates in their study. Participants felt that this was characterized by a steep learning curve and importantly a lack of placement time and variety of settings impacted this. This was demonstrated by participants citing a lack of education regarding the patient journey. Devenish et al. (2016) also suggested the theory-practice gap, and this was especially noted in the post

formal socialization phase after leaving university. This was found during feelings of being thrown in at the deep end and addressing this by spending increased time in ambulance training rooms during this period.

Filstad and McManus (2011) described this theory-practice gap as 'transferring knowledge to knowing', stating that you cannot learn everything through reading and that practice-based learning is important.

Workplace Culture

The final theme of workplace culture relates to the role of the organization or employer that graduates transition into on commencement of employment. This can be considered in positive organizational culture such as both formal and informal support structures (Filstad and McManus, 2011; Devenish et al. 2016) and perceived gaps in workplace settings (Mosiane et al., 2025).

Phillips and Trenoweth (2023) highlighted how supporting graduate paramedics to navigate their new identity would be of benefit to participants, advocating for increased clinical supervision from organizations while recognizing the operational barriers associated with this. Filstad and McManus (2025) advocated for access to experienced staff and that there needs to be formal facilitation of this on the part of the organization itself, rather that the full burden being placed on the individual. In Devenish et al. (2016), graduates found challenges in the initial stages of their intern programs such as exposure to pseudo-military cultures. At the same time, there were benefits through learning formally with peers and allowing this initial period to become an extended period of their university learning.

Thompson (2015) also highlighted the potential benefits of formal programs of support, suggesting that the importance of preceptorship cannot be highlighted enough at this initial challenging time. While Mosiane et al. (2025) found that gaps in mental health provision had a big impact on graduate experiences suggesting that access to formal weekly support from the employer would be of benefit in mitigating the mental health challenges faced. A lack of a formal internship program in South Africa is noted in this study and this manifests in this gap in the support structures required.

DISCUSSION

This review highlights how the graduate journey is challenging but that organizational support and professional relationships can have a positive influence during this time. This builds upon previous paramedic-based reviews which identified emotional support, the need for formal support structures and elements of the theory-practice gap (Kennedy et al. 2015; Hanna et al. 2021).

Professional socialization emerged as a key concept, closely related to identity formation in graduate paramedics. This is reflected in the wider healthcare literature and the concept of adapting to existing cultures is found in several studies (Hunter and Cook 2018, Noble et al. 2014, Lloyd 2009). Hunter and Cook (2018) describe how graduate nurses had to adapt to new cultures within their chosen profession with Feng et al. (2012) using the term 'becoming an insider' with Lloyd (2009) noting this as gaining a 'peripheral identity' which 'legitimizes their place in their new workplace environment'. Existing

literature cautions that professional identity in paramedic practice sometimes focuses on that of the 'Trauma Junkie' (Johnston and Acker, 2016; Palmer, 1983). Sinclair et al. (2025) venture that graduates are 'real paramedics as working for an ambulance service' with Hill and Eaton (2023) countering paramedics should be termed 'generalists' who can be found in a variety of roles.

Phillips et al. (2014) propose that the process of socialization needs to be managed through a formalized model to ensure a smooth transition into autonomous practice for graduate nurses in their study, suggesting that organizations can play a key part in this by ensuring formal orientation programs are made available to graduates. Interestingly, Tong et al. (2022) noted how graduates still identified as students in the first stages of autonomous practice but found that as they were supervised less over time, a shift in professional identity occurred which supported an upturn in their confidence. This highlights the need for evidence-based preceptorship programs which support graduates for individualized periods of time.

While the socialization may facilitate the initial integration into to the paramedic profession it should also be noted that this can result in graduates adapting to negative aspects of culture, for example, becoming pessimistic and disparaging of management (Devenish et al. 2016) This suggests that the process of professional socialization contains within it, negative aspects which graduates are exposed to.

The emotional aspect is prevalent in the transition literature and while there is understandably some focus on traumatic events (Mosiane et al., 2016), a 'steep learning curve' and feelings of being 'overwhelmed' and 'out of my depth' are prevalent and often related to increased complexity of workload (Harvey Lloyd et al. 2019; Chipchase et al. 2022; Stoilkov et al. 2022; Jones et al. 2022; Kennedy et al. 2015). In helping to mitigate for these challenges, O'Grady et al. (2026) found that interactions with mentoring staff would allow participants to develop clinical judgment, helping to manage the complexity of autonomous practice. This supports the need for supportive workplace relationships, highlighting the value of a named mentor / preceptor providing individualized support (Lao et al. 2022; Chipchase et al. 2022; Stoilkov et al. 2022). Kelly and McAllister (2013) found that a 'friendly' relationship between preceptor and preceptee in nursing was a huge benefit to new graduate nurses. Ankers et al. (2018) found that graduate nurses would often seek the support of nurses who they held a rapport with. Likewise, Carver and Lazarsfeld-Jensen (2018) also emphasized the importance of establishing a one-to-one relationship between graduates and paramedic preceptors.

Supportive workplace relationships influence several of the themes identified within this review rather than functioning as an isolated aspect. Lewis et al. (2023) found that adequate support for graduates helped with aspects of the other themes cited, namely that of socialization through identity formation and providing a balance between wanting self-sufficiency while retaining the safety net required to mitigate emotional challenges.

The theory-practice gap extends beyond clinical knowledge and encompasses the realities of autonomous practice. Kennedy et al. (2015) highlighted this as the 'discrepancy between theory and practice' and defined it as the gaps in knowledge which become apparent to newly qualified staff on commencement of their own professional practice. While it would be reasonable to assume shortcomings in education settings, Singh et al.

(2024) found that in nursing graduates the gap was related to misunderstandings of the profession by students during their undergraduate years, with students neglecting to focus on the true essence of the nursing profession, and a lack of quality placements.

Kennedy et al. (2015) similarly argued that variation in placement experiences, including differences in placement hours, clinical exposure, and mentorship quality, contributes to the theory–practice gap experienced by graduate paramedics often encompassed by the term 'transition shock' (Duchscher, 2009; Kramer 1974).

Michau et al. (2009) point out that 'narrowing' this gap is a key factor in transition into graduate practice with Thompson and Houston (2024) advocating for an assessment for a learning model in undergraduate paramedic education ensuring that curriculum is more focused towards the clinical and professional realities of the paramedic profession which address workplace cultures.

Evidence based, structured preceptorship programs could provide one mechanism to ensure organizations can address these challenges with several studies highlighting the value of recognized graduate programs (Kelly and McAllister, 2013; Rush et al., 2019; O'Shea and Kelly, 2007, Sinclair et al. 2025). Salt et al. (2023) also highlighting the importance of profession-specific preceptorship, arguing that programs should be tailored to individual professional groups rather than adopting a generic approach.

The HCPC report in their 2022 'One Year in registration survey' that of 574 participants, only 21% reported a preceptorship of longer than 12 months, with 24% having a duration of less than three months (HCPC, 2022). This review goes on to suggest that longer periods of preceptorship are broadly helpful in graduate development which is echoed by The Royal College of Paramedics (2026) in the UK who suggest a two-year preceptorship period. This supports much of the findings of this review which has noted that socialization, clinical judgment, and identity develop throughout the stages of autonomous practice.

These findings show that the responsibility for addressing this gap is multi-faceted, with higher education, graduates, and employers all having a responsibility to amend their provision. Consequently, effective preceptorship may support not only the development of clinical competence but also professional socialization, supportive workplace relationships and the management of the emotional burden associated with autonomous practice, highlighting the interconnected nature of the themes identified within this review.

LIMITATIONS

Limiting to the English language introduces potential bias in the results, additionally, it is acknowledged that excluding gray literature may have implications for the findings. Included studies originate from predominantly high and upper middle-income countries which potentially limits application globally. One of the studies was authored by a member of the review team, however, this was mitigated through multi-reviewer screening processes.

CONCLUSIONS

This review has explored the transition experiences of graduate paramedics and identified that professional socialization, identity formation, workplace relationships, emotion-

al wellbeing, and the theory–practice gap all influence this period of development. The findings suggest that structured support, for example, through profession-specific preceptorship, has the potential to mitigate some of the challenges experienced during the transition to autonomous practice. While graduates have an important role in their own professional development, organizations also have a responsibility to establish appropriate support structures that facilitate confidence, competence, and wellbeing. Future approaches should recognize the unique challenges faced by graduate paramedics and consider how preceptorship programs can be optimized to support their needs. Further research is required to evaluate existing programs from the perspective of graduates and preceptees, ensuring that organizational approaches are informed by the experiences of those undergoing transition.

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APPENDIX

Data Extraction Table

Paper	Study Information	Details
Devenish, A, Clark, MJ and Fleming, M (2016) Location: Australia	Study Type: • Qualitative data using deductive process to test existing socialization model Participants: • 34 participants. 19 participants were newly graduated paramedics. Study Methods: • Participant interviews lasting 30 to 60 minutes in length.	Transition Experiences: • Becoming a paramedic was described as a process of professional socialization rather than simply acquiring clinical competence. Transition occurred through several developmental phases. • Graduates in particular cite post formal socialization and post internship phases. Transition Challenges: • Reconciling academic learning with workplace realities - Theory - practice gap. • Adapting to organizational culture. • Limited feedback from supervisors. Facilitators: • workplace learning (exposure) • mentoring relationships, experiential learning - end of internship year following increased exposure. Preceptorship Experiences: • Internship shown to be of benefit but was followed by another period of socialization. Themes: • Professional socialization, workplace culture.
Filstad, C and McManus, J (2011) Location: Oslo, Norway	Study Type: • Ethnographic Study Participants: • 12 Newly graduated paramedics. Between 1-12 months experience Study Methods: • 12 semi-structured and unstructured interviews. • 2 focus groups: 6 participants each. • Participants were also observed on shift by study team.	Transition Experiences: • NQPs transition as a process of moving from theoretical knowledge to practical competence. • Early transition characterized by learning the "code" of the ambulance service and gradually moving from peripheral participation to becoming a trusted member of the team. Transition Challenges: • Key barriers included adapting to an established organizational culture, coping with emotional demands, and gaining acceptance from experienced colleagues. Newcomers reported stress from constant evaluation by peers and uncertainty about social expectations. Access to learning opportunities was not always automatic; acceptance by colleagues often had to be earned. Participants emphasized that failing to understand the station's humor, norms, and culture could lead to exclusion. Emotional challenges included managing reactions to traumatic incidents and preventing emotions from interfering with clinical decision-making. Some participants noted that discussing vulnerability openly was difficult, particularly with people they did not yet trust. Facilitators: • Support from experienced colleagues, especially assigned partners, was the most important facilitator. Observation, participation in real callouts, and gradual exposure to responsibility allowed newcomers to develop confidence while reducing stress. Informal learning opportunities, such as conversations with colleagues. Social support within the team was highly valued, with the workplace often described as a "family." Trusting relationships enabled emotional debriefing, practical guidance, and access to tacit knowledge that could not be learned from textbooks. Preceptorship Experiences: • Does not specifically use the term preceptorship, the role of experienced staff closely resembles a preceptor model. Participants reported relying more heavily on their partner for emotional processing and feedback than on formal organizational debriefing systems. Having an established partner was viewed as essential. Themes: • Knowledge to Knowing • through active involvement in workplace communities. • Professional Socialization: understanding organizational norms, values, and expectations and becoming accepted by the group. • Relational Learning: Access to experienced colleagues and supportive relationships is key. • Emotional Management: Developing strategies to manage emotional responses was essential for safe and effective practice. • Identity and Belonging: Becoming a paramedic as a member of a family.

Paper	Study Information	Details
Mosiane, A, McInerney, P and Sobuwa, S Location: South Africa	Study Type: • Critical theory paradigm Participants: • 4 newly qualified paramedics. 10 experienced paramedics not included in analysis. Study Methods: • Participants were interviewed at commencement of employment, 3 month one to one interviews, 3-month focus group, 5 month one to one interviews and 12-month final group discussion.	Transition Experiences: • Transition characterized by adjustment to professional responsibility and operational realities. Newly qualified paramedics (NQPs) reported significant psychological and emotional strain during early practice. Transition Challenges: • Mental health difficulties, exposure to trauma, stress, emotional exhaustion, workload pressures, adapting to autonomous decision-making. Facilitators: • Peer support, organizational support, mentorship, wellbeing initiatives. Preceptorship Experiences: • Highlights the need for structured support during transition; formal support systems may mitigate psychological distress. Themes: • Emotional burdens: Mental health, wellbeing, transition stress, support needs.
Phillips, P and Trenoweth, S. (2023) Location: United Kingdom	Study Type: • Mixed methods study Participants: • 18 newly qualified paramedics Study Methods: • Mixed methods. Quantitative data used Connor-Davidson resilience scale. • Qualitative data used semi-structured interviews.	Transition Experiences: • Participants described transition as uncertain, emotionally challenging, and non-linear. The metaphor of a "flaky bridge" reflected feelings of instability between student and practitioner identities. Described as emotional turbulence Transition Challenges: • Fear of clinical errors, self-doubt, responsibility for patients, lack of confidence. Facilitators: • Supportive colleagues, reflection on identity, organizational support, opportunities to gain experience safely. • Catalyst event supports successful transition. Preceptorship Experiences: • Not explicitly mentioned but mentioned the value in support from senior colleagues. Themes: • Emotional turbulence, increased responsibility, • Socialization through identity.
Thompson, S. (2015) Location: United Kingdom	Study Type: • Qualitative study using focus groups Participants: • 4 newly qualified paramedics Study Methods: • Focus group using semi-structured question guide	Transition Experiences: • Concerns about readiness for practice and professional responsibility. • Professional registration responsibilities. Transition Challenges: • Clinical decision-making, accountability, confidence, fear of making mistakes, managing emergencies independently. • Confidence to deal with other ambulance staff. Facilitators: • Guidance from experienced colleagues even if less scope of practice. • Ongoing professional development opportunities around patient journey. Preceptorship Experiences: • Implied importance of structured support mechanisms although preceptorship was not the primary focus. Preceptorship mentioned in discussion. Themes: • Confidence, responsibility, support needs.

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RESEARCH REPORTS

GLOBAL PARAMEDICINE AND EMS DOCTORATES: A REGISTRY-BASED ANALYSIS

Brett Williams, PhD, FACP*[1]

Author Affiliations: 1. Department of Emergency Medical Care, College of Applied Medical Sciences, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia.

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*Corresponding Author:
bawilliams@iau.edu.sa

ABSTRACT

Background: Doctoral education is an indicator of research capacity and professional maturation. However, the global scope and characteristics of paramedicine/EMS doctorates have not previously been systematically described.

Methods: A global registry-based study of completed doctoral dissertations authored by paramedics, EMTs, or other health professionals working in the out-of-hospital setting was undertaken using systematic searches of dissertation databases, repositories, registry sources, and stakeholder verification.

Results: A total of 406 completed paramedicine/EMS doctoral dissertations were identified. Completions increased substantially after 2010, with most conferred in the USA, Australia, and the UK. PhDs accounted for the majority (n=305; 75.1%), while professional doctorates comprised 81 dissertations (20.0%) and were concentrated in the USA (n=63; 77.8% of professional doctorates).

Conclusion: Paramedicine/EMS doctoral output has grown substantially but remains clustered in a small number of countries and institutions. The registry offers a practical baseline for showing where doctoral activity is already established, identifying where supervision capacity remains limited, and where future doctoral pathways may need support.

INTRODUCTION

Paramedicine and emergency medical services (EMS) have progressively transitioned from a mainly vocational workforce to a university-based health profession with growing roles in education, research, and leadership (Polat & Köse, 2025). In health professions, doctoral education is commonly used as an indicator of disciplinary maturity and long-term research capacity (Eaton, 2019; Hill & Eaton, 2023). In established health professions such as nursing and physiotherapy, dissertation-based analyses have been used to benchmark doctoral activity and identify research priorities, with previous studies reporting on areas such as patient care, education, professional development, and movement-related scholarship. Comparable international benchmarking has been lacking for paramedicine/EMS despite

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sustained growth in peer-reviewed scholarship (Beovich et al., 2021; Stolt et al., 2017; Wikström-Grotell et al., 2018).

This study developed a global registry of completed paramedicine/EMS doctorates. The aims of the study were to quantify doctoral output over time, describe its distribution by country and institution, compare doctorate types, and profile primary supervisor backgrounds and title-derived research themes. Recent work has reported on paramedicine doctorates through the voluntary, self-reported Paramedic PhD registry, which provides a useful but incomplete overview of doctoral activity because it relies on self-submission and variable updating (Whitley, 2025).

Voluntary self-reporting registries are vulnerable to incomplete capture, self-selection, and inconsistent follow-up, which can reduce coverage and affect the accuracy of population profiling (Gilbert et al., 2018; Harron et al., 2020). For this reason, a multi-source registry can move the discussion beyond who has self-submitted their details and towards a more defensible estimate of the field's doctoral activity. This study extends Whitley's (2025) overview by applying a structured, multi-source registry methodology to identify a more comprehensive global count of completed paramedicine/EMS doctorates.

METHODS

Study Design and Reporting

A descriptive registry-based study was undertaken of completed doctoral dissertations authored by paramedics, EMTs, or other health professionals clearly evidenced as working in the out-of-hospital setting. Searches were conducted across ProQuest Dissertations & Theses Global, EBSCO OpenDissertations, Open Access Theses and Dissertations (OATD), Trove, NZResearch, CiNii Dissertations, and Figshare, supplemented by registry sources, selected institutional repositories, and targeted web searches. Search concepts combined paramedicine/EMS terms with doctoral dissertation terms and were adapted for each database. No date restrictions were applied to the search. Targeted engagement was undertaken via social media and direct email to international contacts and professional networks to identify additional eligible records not captured through database and repository searches. Given the registry-based design, a formal PRISMA review flow was not applied; however, registry sources, eligibility, verification process, missing data, and key reproducibility limits are reported.

Eligibility Criteria

Eligibility was determined based on explicit information within the dissertation record, including author credentials, professional affiliation, or evidence of an out-of-hospital clinical role. For this study, out-of-hospital was interpreted as paramedicine, EMT, ambulance, prehospital, emergency medical services, retrieval, transport, community paramedicine, or comparable field-facing clinical practice. Authors working in hospital roles were included only where the available record also showed a clear EMS or out-of-hospital professional background; hospital-only health professionals were excluded unless this link could be verified. Dissertations were included only where completion status could be verified through repository or catalogue records. Records were excluded if they were in progress, unpublished, or lacked sufficient evidence to confirm the author's professional background as a paramedic, EMT, or other out-of-hospital health professional. Dis-

sertations authored by individuals from other health professions without clear evidence of out-of-hospital clinical practice were also excluded.

Screening and Data Extraction

Records were screened against predefined eligibility criteria and manually confirmed where required. Potential duplicates were checked using author name, dissertation title, institution, completion year, and source record, with manual review used where records appeared under different repository or catalogue formats. Suggested records from stakeholder contact were retained only when they could be checked against a public repository, catalogue, institutional profile, or dissertation record. Screening and classification were undertaken by the author; therefore, formal inter-reviewer agreement statistics were not calculated. Extracted variables included author, doctorate title, university, country, completion year, doctorate type, supervisor profession, and source. Provisional registry outputs were circulated to international stakeholders so missing records could be verified against repository or catalogue evidence. Analyses were descriptive. Available dissertation titles were reviewed descriptively and grouped inductively into broad themes. Title-derived themes were generated by the author through iterative review and refinement of dissertation titles. The final registry was maintained in a version-controlled spreadsheet, and descriptive summaries were produced for year of completion, country, doctorate type, awarding institution, supervisor profession, and title-derived themes.

RESULTS

The registry identified 406 unique completed paramedicine/EMS doctoral dissertations between 1983 and 2025, with a median completion year of 2018 (Figure 1). Where year data were available (n=387), growth accelerated after 2010, with 179 dissertations completed in 2010–2019 and 167 in 2020–2025. This indicates that most doctoral production has occurred within a relatively recent period of professional development and transition to university-based education.

Doctorates were awarded across 20 countries (country recorded for n=385). The USA contributed 132, Australia 82, and the UK 47, together accounting for almost two-thirds of identified output (Table 1). Missing data were retained in the registry rather than imputed; country and institution were unavailable or unverified for 21 records, completion year for 19 records, supervisor profession for 19 records, and title data for 54 records.

PhDs accounted for 305 dissertations (75.1%) and professional doctorates for 81 (20.0%), with professional doctorates concentrated in the USA (Table 2). Specific PhD program labels, such as public health, education, rehabilitation science, or interdisciplinary studies, were not consistently reported in repository records and were too heterogeneous for reliable categorization. For this reason, the analysis was limited to doctorate type rather than named PhD program stream.

Decadal distribution is summarized in Table 3, highlighting the concentration of completions in the 2010s and 2020–2025 period among records with year data available. The decade categories refer to completion year ranges: 1980=1980–1989, 1990=1990–1999, 2000=2000–2009, 2010=2010–2019, and 2020=2020–2025.

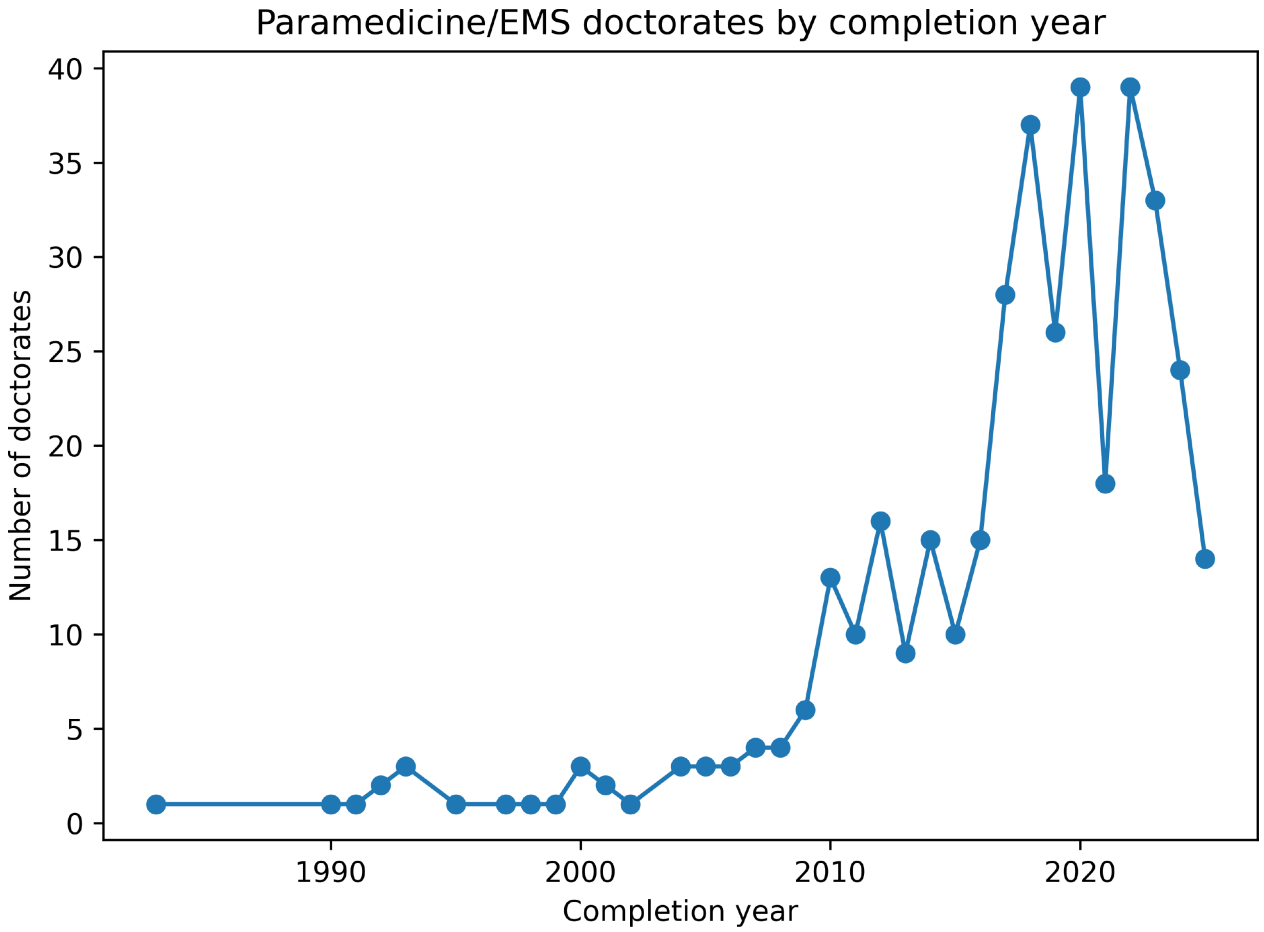


Figure 1. Time series of doctorates by completion year.

Country	*n*	%
USA	132	32.5
Australia	82	20.2
UK	47	11.6
Saudi Arabia	24	5.9
Canada	22	5.4
South Africa	21	5.2
Japan	17	4.2
NZ	8	2.0
Thailand	6	1.5
Jordan	6	1.5
Ireland	5	1.2
Germany	3	0.7
Poland	3	0.7
Hungary	2	0.5
Finland	2	0.5
Israel	1	0.2
Italy	1	0.2
Austria	1	0.2
Denmark	1	0.2
Taiwan	1	0.2

Table 1. Doctorates by country (n=406).

Country	PhD	Professional Doctorate
Australia	78	4
USA	69	63
UK	41	6
Saudi Arabia	24	0
South Africa	21	0
Japan	17	0
Canada	16	6
NZ	8	0
Jordan	6	0
Thailand	6	0
Ireland	4	1
Germany	3	0
Poland	3	0
Hungary	2	0
Austria	1	0
Denmark	1	0
Finland	1	0
Israel	1	0
Taiwan	1	0
Italy	0	1

Table 2. Degree type by country (PhD vs professional doctorate).

Decade (Completion Year Range)	n	%
1980 (1980–1989)	1	0.2
1990 (1990–1999)	11	2.7
2000 (2000–2009)	29	7.1
2010 (2010–2019)	179	44.1
2020 (2020–2025)	167	41.1

Table 3. Doctorates by decade.

The most frequent awarding institutions were Monash University (Australia), Capella University (USA), and Kokushikan University (Japan). Institution data were available for 385 records; Table 4 excludes 21 records with missing or unverified institution data.

University	Country	n	%
Monash University	Australia	33	8.1
Capella University	USA	16	3.9
Kokushikan University	Japan	15	3.7
University of Cape Town	South Africa	8	2.0
Queensland University of Technology	Australia	6	1.5
Texas A&M University	USA	6	1.5
Auckland University of Technology	NZ	5	1.2
Flinders University	Australia	5	1.2
University of Maryland	USA	5	1.2
Walden University	USA	5	1.2

Table 4. Top 10 awarding universities.
Note: excluding missing data.

Primary Supervisor Profession Profile

Among records with supervisor information (n=387), the most common primary supervisor professions were medicine (n=165; 42.6%), education (n=70; 18.1%), psychology (n=34; 8.8%), paramedicine (n=28; 7.2%), and nursing (n=23; 5.9%). The pattern indicates that doctoral supervision in paramedicine continues to rely heavily on cognate disciplines, although paramedicine-trained supervisors are becoming more common.

Title-Derived Thematic Profile

Available dissertation titles (n=352) were reviewed and grouped into five broad title-derived themes: time-critical clinical care; education, training, and simulation; workforce and professional issues; systems, service delivery, and governance; and patient safety and quality-focused practice. Together, these themes indicate that paramedicine doctoral research spans clinical priorities as well as professional development, system design, and service quality.

DISCUSSION

This study provides the first systematically derived multi-source profile of completed doctorates and shows rapid increase in doctoral activity over the last 15 years. At the same time, doctoral output remains clustered in a limited number of countries and universities. This pattern is encouraging, but it also shows that doctoral development in paramedicine/EMS has not advanced evenly across countries (Beovich et al., 2021).

The post-2010 rise in doctoral completions likely reflects the continued professionalization of paramedicine, the expansion of university-based education, and increasing expectations for research-qualified leaders in both academic and clinical settings (Meadley et al., 2022). It may also reflect stronger institutional acceptance of paramedicine as a legitimate health profession, with more candidates able to pursue doctoral study within, or closely aligned to, their professional discipline (Maruši , 2013; Meadley et al., 2022).

The geographic concentration of doctorates in the USA, Australia, and the UK suggests that doctoral capacity develops where higher education pathways, supervision expertise, and research infrastructure are already established. Emerging output from other regions indicates widening international engagement, but capacity remains uneven (Beovich et al., 2021). For countries seeking to build their own doctoral ecosystems, the findings

highlight the importance of aligned workforce planning, academic career structures, and institutional commitment (Ross et al., 2023; Simpson et al., 2023).

This concentration has applied implications. Countries with only a small number of doctorates may struggle to build local supervision capacity, develop paramedicine-led research groups, or offer clear academic career pathways for clinicians who want to move into doctoral study. For universities and EMS systems, the findings suggest that doctoral growth is unlikely to occur through individual motivation alone; it will also require scholarships, protected research time, formal supervision development, and stronger links between ambulance services and higher education institutions.

PhDs were the dominant pathway, suggesting that doctoral development in paramedicine/EMS remains primarily research oriented. Professional doctorates appear to serve a more applied role and were heavily concentrated in one national context, indicating important international differences in doctoral structures (Dennis et al., 2024). These differences are important because they may shape the kinds of leadership and scholarship produced by doctoral graduates (Kim et al., 2022; Maruši , 2013).

A relatively small number of universities appear to function as key doctoral hubs. These universities appear to be places where candidates can find the supervision, research culture, and institutional familiarity needed to complete doctoral work in this field. For newer programs, an important lesson may be how these universities build supervisory teams, support early-career academics, and connect paramedicine candidates with experienced researchers from related disciplines (Simpson et al., 2023; Stolt et al., 2017).

For paramedicine to supervise more of its own doctoral work, the profession will need more doctoral-qualified paramedics who are supported to take on primary supervision roles. This includes expanding the pool of PhD-qualified paramedicine academics, embedding co-supervision and mentorship, and providing protected time, workload recognition, and targeted funding for paramedicine-led research programs (Ross et al., 2023). Such developments are likely to be important to the next stage of professional maturation (Meadley et al., 2022).

LIMITATIONS

Limitations include variable repository coverage, incomplete indexing, and the possibility that some doctorates were missed or lacked sufficient metadata for classification. In some cases, supervisor profession, year, country, or institution details were unavailable or uncertain. Because the registry was developed iteratively from multiple dissertation databases, repositories, registries, institutional searches, and stakeholder-identified records, exact source-level retrieval and exclusion counts were not available. This limits the ability to quantify how many records were excluded for each eligibility reason. The eligibility criteria were restricted to formally completed and publicly available dissertations authored by paramedics, EMTs, or other health professionals clearly evidenced as working in the out-of-hospital setting; however, classification remained dependent on the completeness and clarity of available repository metadata and may have resulted in the exclusion of records where professional background could not be definitively established. In addition, reliance on publicly available records may have limited the identification of dissertations not indexed or accessible through searchable repositories or networks. As screening and thematic grouping were undertaken by the author, the

study also did not calculate inter-reviewer agreement; this should be considered when interpreting the classification of supervisor background and title-derived themes.

Further research should look more closely at the practical barriers that potential doctoral candidates face, particularly access to supervisors, funding, protected time, and visible academic career pathways. For universities, this may include creating co-supervision arrangements that pair emerging paramedicine academics with experienced supervisors from cognate disciplines. For professional organizations, it may include maintaining doctoral registries, profiling doctoral graduates, and advocating for funded doctoral pathways. For EMS systems, it may include recognizing doctoral training as part of workforce planning rather than as an individual career activity undertaken outside normal service priorities. Research is also needed on how doctoral training influences academic leadership, workforce development, and service improvement. Ongoing maintenance of the registry would allow longitudinal benchmarking of growth, international spread, and shifts in doctoral themes over time.

CONCLUSION

Global paramedicine/EMS doctoral output has grown rapidly over the past 15 years, reflecting increasing research capacity and disciplinary development. The next challenge is to ensure that this growth is not confined to a small group of countries but is supported through stronger supervision pipelines and more visible paramedicine-led research infrastructure. A practical next step is for universities, professional bodies, and EMS employers to treat doctoral training as part of long-term workforce and research strategy, rather than as a small number of isolated individual achievements. A maintained global registry provides a basis for tracking that progress.

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REVIEWS

DEFINING ENTRY-TO-PRACTICE COMPETENCE IN PARAMEDICINE: A SCOPING REVIEW

David Page, MS, NRP[1,2]; Brett Williams, PhD, FACP*[3]

Author Affiliations: 1. Prehospital Care Research Forum, David Geffen School of Medicine, University of California Los Angeles (UCLA), Los Angeles, CA, USA; 2. Emergency Medical Services, Allina Health, Minneapolis, MN, USA; 3. Department of Emergency Medical Care, College of Applied Medical Sciences, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia.

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**Corresponding Author:* bawilliams@iau.edu.sa

ABSTRACT

Objectives: Paramedics play a key role in unplanned, emergent, and episodic out-of-hospital health care. A comprehensive description of the minimally expected competencies (knowledge, skills, and attributes) necessary to perform the duties of a paramedic is required to build effective education programs and credentialing systems. This scoping review aimed to map and synthesize the literature describing entry-to-practice competence in paramedicine, including professional expectations and approaches used to assess readiness for independent practice.

Methods: A structured search of MEDLINE, EMBASE, Scopus, CINAHL, Google Scholar, and greylit.org was undertaken for literature published between 1996 and 2026. The search included peer-reviewed literature published between 1 January 1996 and 1 January 2026.

Results: The four databases identified 8,231 records. After duplicates were removed, 6,755 records were screened and 99 full-text reports assessed. Twenty studies were identified through database searching and two additional studies through supplementary searching, resulting in 22 included studies. Three domains were identified: desirable non-technical attributes and professionalism, scope of practice, and assessment of competency. Secondary domains were assigned where studies addressed more than one area.

Conclusions: Entry-to-practice paramedic competence is consistently described across three interrelated domains: desirable non-technical attributes and professionalism, scope of practice, and assessment of competency. These findings can inform curriculum design, accreditation, and workplace-based assessment approaches in paramedicine.

INTRODUCTION

Paramedics and the out-of-hospital services they provide are increasingly being considered an essential component of health care systems worldwide (Bhattarai et al., 2023). In countries with developed emergency medical care systems, the public has come to expect that a single call to a universal phone number will rapidly bring competent and well-equipped health providers to their side (Crowe et al., 2016). Recent work has also shown considerable variation in paramedic system design, including differences in professional autonomy, governance, and work-

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force organization (Makrides et al., 2022, 2023). This expectation not only creates an economic and logistical challenge but also an education and performance verification challenge. This variation in paramedic roles, professional expectations, and models of practice presents challenges for educators and workforce planners across different health systems (Batt et al., 2025; Bhattarai et al., 2023). Further, because paramedics respond to life-threatening emergencies, reasonable competence of the provider is a clear public expectation. This has led to the registration of paramedics as health care professionals in a number of jurisdictions (e.g., Australia, Canada, Ireland and the United Kingdom) (Reed et al., 2022; Weber et al., 2024a). Without an appropriately identified competency framework required for professional practice, downstream activities such as curriculum development and assessment of competence can compromise the care and safety of the public (Batt et al., 2020).

Competency frameworks are commonly part of health professions and ensure the identification of abilities and competency-based standards needed for effective professional practice (Batt et al., 2020; Gonczi et al., 1990). In this model, a professional role/profile is constructed by describing required behavioral objectives in the form of knowledge, skills, attitudes, and other characteristics (KSAOs) for effective practice (Campion et al., 2011). Paramedic education and entry-to-practice requirements vary internationally. Degree-based education and professional regulation are established in several jurisdictions, while vocational, technical, and mixed pathways remain elsewhere (Makrides et al., 2022). In Australia, the United Kingdom and Ireland, paramedicine is a regulated health profession with registration, accreditation and defined professional standards or capabilities (Health & Care Professions Council, 2023; Paramedicine Board of Australia, 2020; Pre-Hospital Emergency Care Council, 2026). Other systems use different educational and credentialing models. These differences affect how entry-to-practice expectations are defined and assessed. The structure of KSAOs broadly reflects established domains of learning: the cognitive domain described by Bloom et al. (1956), the affective domain developed by Krathwohl et al. (1964), and the psychomotor domain, for which several taxonomies have been proposed, including those of Dave (1970), Harrow (1972), and Simpson (1972). The identification of KSAOs ensures healthcare professions are well defined, promotes competent workforces, facilitates assessment, facilitates professional mobility, and helps to analyze and evaluate the expertise of the profession and the professional (Campion et al., 2011; Epstein & Hundert, 2002; Gonczi et al., 1990). KSAOs in paramedicine should be informed by a holistic role description to avoid becoming too reductionist. Paramedic practice requires the performance of multiple competencies at once, which KSAO frameworks run the risk of not capturing.

Contemporary approaches to health care professional education have embraced the concept of competency-based medical education (Frank et al., 2010; Van Melle et al., 2019). While not necessarily the only approach, Heywood et al. (1992) describes many benefits of having a set of competencies that describe entry-level practice, and the specified performance standard to assess their attainment. Among these benefits, Heywood lists consistent recognition across jurisdictions, accreditation standards, articulation with overseas education and related occupations, open and equitable assessment, and progression within an industry (Heywood et al., 1992).

Definition of Terms

In this review, entry-level refers to the point at which a trained paramedic is expected to practice without direct supervision (Tavares & Boet, 2016). Depending on the jurisdiction, this may follow graduation, registration, or credentialing, with scope of practice determined by the relevant regulatory or service framework. In this review the concept of competency or competence was defined as proficiency and accuracy in the ability to perform not only task-based technical procedures but also higher-order thinking and behavioral skills such as professionalism, judgment, clinical decision making, communication, ethical practice, collaboration, and leadership (Epstein & Hundert, 2002). For this review, competence is used as an umbrella term for the minimum expectations for safe and effective entry-to-practice (Epstein & Hundert, 2002). Across jurisdictions, these may be expressed as competencies, professional capabilities, standards of proficiency, scope-of-practice requirements, or other professional standards. The terms are not interchangeable but reflect differences in how paramedic practice is defined and regulated.

The purpose of this scoping review was to map and synthesize the nature of literature describing entry-to-practice competence in paramedicine, including professional expectations and approaches used to assess readiness for independent practice. It was not intended to propose a universal assessment framework or replace jurisdiction-specific professional standards, capabilities, or registration requirements.

METHODS

Design

This scoping review was conducted using the framework described by Arksey and O'Malley (2005) with methodological refinements proposed by Levac et al. (2010) and guidance from the Joanna Briggs Institute Manual for Evidence Synthesis (Peters et al., 2020). Reporting followed the PRISMA Extension for Scoping Reviews (PRISMA-ScR). The protocol was registered with the Open Science Framework (https://osf.io/m6h8c).

Research Question

"How is entry-to-practice competence in paramedicine described in the literature?"

Identify Relevant Studies

A structured search was conducted across MEDLINE, EMBASE, Scopus, and CINAHL, supplemented by searches of Google Scholar and greylit.org. Additional literature was identified by hand searching the reference lists of included studies (Paez, 2017). The search strategy was developed using the Population–Concept–Context (PCC) framework, consistent with scoping review methodology (Peters et al., 2020).

Population (P): paramedics and jurisdictional equivalents (e.g., emergency medical technicians [EMTs] and emergency medical services [EMS] clinicians) practicing in the prehospital or out-of-hospital setting.

Concept (C): expected entry-to-practice competence, including competency frameworks, competency profiles, standards, scope-of-practice statements, graduate attributes, and competency assessment approaches used to determine readiness for independent practice.

Context (C): entry-level practice, defined as the point of graduation, initial registration, or first independent practice without direct supervision.

The optimized paramedic literature search filter by Olaussen et al. (2017) was utilized. This validated filter was combined with keywords and subject headings relating to competence and competency (e.g., competence, competency, standards, capability, attribute, scope of practice) and entry-to-practice concepts (e.g., entry-level, graduate, newly qualified, novice).

All database and supplementary searches were completed on 1 January 2026. Citations were imported into Zotero, then uploaded to the web-based application Rayyan, where duplicates were removed prior to screening. For Google Scholar, predefined search strings were used and the first 200 results per string were screened (sorted by relevance), with the same eligibility criteria applied as for database records. For greylit.org, keyword searches were undertaken and all returned items were screened (Rethlefsen et al., 2021).

Eligibility Criteria

The search was restricted to peer-reviewed publications in English (including literature reviews, qualitative, quantitative, and mixed-methods studies) published between 1 January 1996 and 1 January 2026. Editorials, opinion pieces, news stories, interviews, and non-English articles were excluded.

Studies were eligible if they included paramedics/EMTs and described expected entry-to-practice competence at the point of independent practice. This included competency frameworks, profiles, standards, scope statements, and approaches used to assess readiness for practice, such as workplace-based assessment tools, global rating scales and programmatic assessment. See Table 1.

PCC Element	Search Terms
Population (Paramedics/EMS clinicians)	Ambulances.sh OR Emergency Medical Technicians.sh OR Air Ambulances.sh OR Emergency Medical Services.sh OR paramedic*.tw OR paramedicine.tw OR EMT.tw OR EMS.tw OR prehospital.tw OR pre-hospital.tw OR out-of-hospital.tw OR first responder*.tw OR ambulance*.tw OR HEMS.tw
Concept (Entry-to-practice competence)	competenc* OR competence OR competency OR standards OR capability OR attributes OR scope of practice OR professional profile OR graduate attributes OR framework OR assessment OR workplace-based assessment OR global rating scale
Context (Entry-level / Independent practice)	entry-level OR entry level OR graduate OR newly qualified OR novice OR initial registration OR independent practice OR transition to practice

Table 1. Search strategy structured using PCC framework.

Limits Applied

- English language only
- Peer-reviewed literature
- Publication date: 1 January 1996 – 1 January 2026
- Excluded: editorials, opinion pieces, news articles, and single discrete clinical procedures

Entry-level was operationalized as new graduates, students at the point of graduation, initial registration, or the first year of independent practice, and studies were included if

the competency framework or assessment approach was intended to represent minimum competence at initial independent practice.

Studies limited to a single discrete clinical procedure or technical task (e.g., one intervention) or focused on specialist/advanced practice domains not intended for entry-level practitioners were excluded. Studies focused on continued competence, skill maintenance/erosion, or post-registration upskilling were excluded unless they explicitly defined entry-to-practice competence expectations.

Title and Abstract Screening

Two investigators independently screened titles and abstracts, and then independently assessed the full text of potentially eligible articles. Study selection involved an iterative process to refine screening rules. Disagreements were resolved through discussion until consensus was achieved.

Expert Consultation

Three subject matter experts were invited to review the final included articles and provide additional references. No additional papers were suggested.

Charting the Data

Data were extracted using a standardized charting form including: author, year, country, setting, population/role label (paramedic/EMT), study design, how competence was defined, competency framework/domain structure and/or assessment approach, and extracted competency statements/domains.

Critical Appraisal

Formal critical appraisal was not undertaken. As the purpose of the review was to map the extent, characteristics, and content of the literature, studies were not rated or weighted according to methodological quality.

Synthesis

Findings were synthesized using descriptive mapping and an inductive thematic approach informed by Braun and Clarke (2006). This approach was used to identify recurring patterns across the competency statements, professional expectations and assessment constructs extracted from the included studies, rather than to generate themes from primary qualitative data. DP undertook the initial coding of the extracted material, with BW providing a second-reviewer check of the coding and developing domains. Coding was iterative, with related codes grouped and refined into broader domains, and differences in interpretation resolved through discussion and consensus. The final domains were reviewed against the extracted data for coherence and distinction, resulting in three domains:

- Desirable non-technical attributes and professionalism;
- Scope of practice;
- Assessment of competency.

A secondary domain was assigned where a study substantively addressed more than one domain, allowing cross-cutting content to be represented.

RESULTS

The four database searches (MEDLINE, EMBASE, Scopus, and CINAHL) identified 8,231 records. After 1,476 duplicates were removed, 6,755 records were screened, of which 6,653 were excluded. Of 102 reports sought for retrieval, three were not retrieved, leaving 99 full-text reports assessed for eligibility. Seventy-nine reports were excluded following full-text assessment, leaving 20 studies identified through the database searches. Supplementary searching of Google Scholar and greylit.org identified 33 records, from which two additional eligible studies were included. Overall, 22 studies were included in the final synthesis. See Figure 1 for the PRISMA flow diagram (Page et al., 2021).

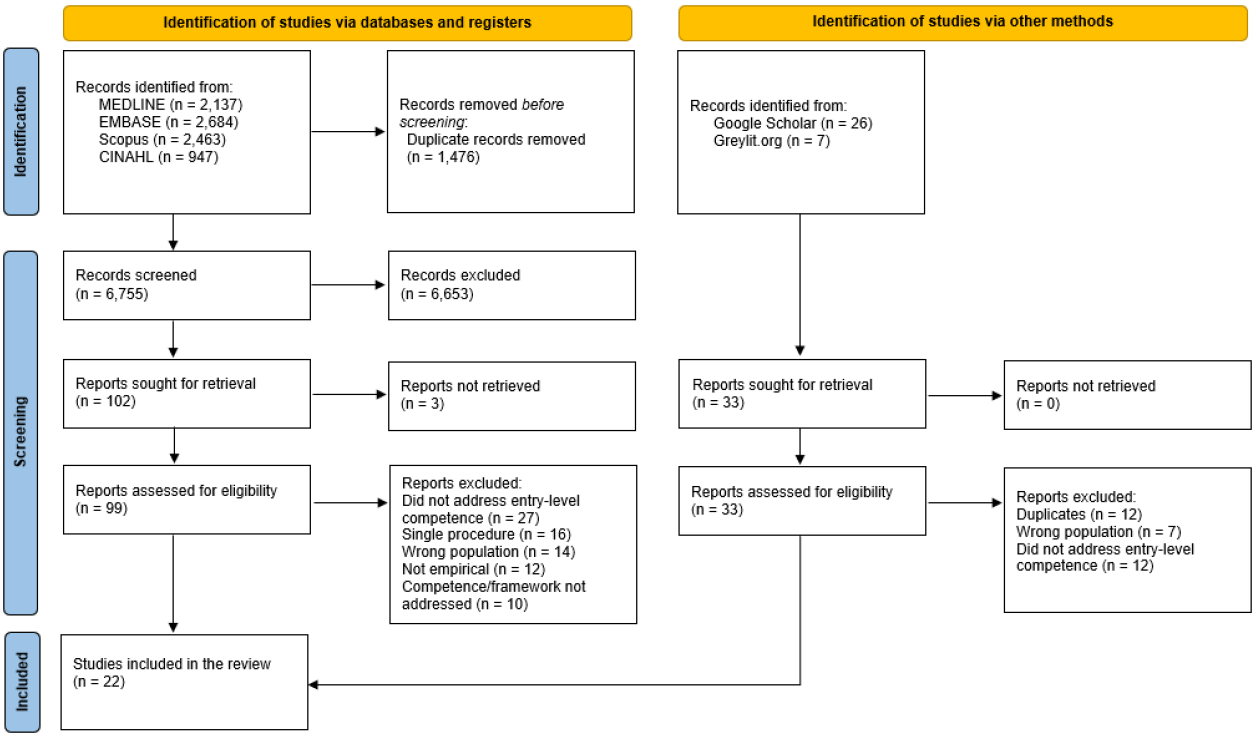


Figure 1. PRISMA flowchart.

Characteristics of Included Studies

This review found 22 relevant publications from five countries/jurisdictions. The majority of the studies were from Canada (*n*=7), followed by Australia (*n*=6), the United Kingdom (*n*=5), Saudi Arabia (*n*=3), and Taiwan (n=1). The methods used included reviews/scoping or systematic approaches (*n*=9), Delphi studies (*n*=3), factor analytic approaches (*n*=3), mixed-methods studies (*n*=2), qualitative or grounded-theory approaches (*n*=2), survey-based studies (*n*=1), data triangulation (*n*=1), systems-thinking (*n*=1), and competency framework development (*n*=1).

Studies were classified by primary domain as desirable non-technical attributes and professionalism (*n*=11), scope of practice (*n*=7), and assessment of competency (*n*=4). Secondary domains were recorded where studies substantively addressed more than one area. Across studies, competency-related content was derived using diverse approaches reflecting variation in how "entry-level competency" was operationalized internationally.

Table 2 summarizes included studies and key extracted elements. Literature also spans major changes in paramedic education and regulation. Earlier studies, particularly from Australia and the United Kingdom, reflect workforce and education systems that pre-date current registration and professional capability frameworks. They were retained to show how entry-to-practice expectations have developed over time but were interpreted within their historical context.

Author	Year	Country	Methods	Key Contribution	Domain(s)
AlShammari et al.	2018	Saudi Arabia	Scoping review	Synthesized international statements to propose core entry-level competencies and themes for Saudi paramedicine.	Desirable non-technical attributes and professionalism
AlShammari et al.	2019a	Saudi Arabia	Delphi study	Delphi consensus ranking of core competencies; emphasized legal/ethical practice, safety, respect, judgement, and clinical care.	Desirable non-technical attributes and professionalism
AlShammari et al.	2019b	Saudi Arabia	Confirmatory factor analysis	A CFA of the SPECS model confirmed five factors: professionalism, preparedness, communication, clinical, and personal.	Desirable non-technical attributes and professionalism Secondary Domain: Scope of practice
Bennett et al.	2021	Australia	Scoping review	Scoping review of paramedic NTS; found limited measurement/assessment despite emphasis on decision-making and communication.	Desirable non-technical attributes and professionalism Secondary Domain: Assessment of competency
Chang et al.	2018	Taiwan	Cross-sectional survey with principal component analysis	Surveyed EMT instructors and medical directors and used principal component analysis to derive core competency factors across Taiwanese EMT levels; also identified perceived gaps in training, licensure, and system development.	Desirable non-technical attributes and professionalism Secondary Domain: Scope of practice
Cooper	2005	United Kingdom	Qualitative interview-based study	Explored professional competence needs and CPD in a changing service context; raised concerns about assessment validity/reliability.	Desirable non-technical attributes and professionalism Secondary Domain: Assessment of competency
Kilner	2004	United Kingdom	Delphi study	UK Delphi of graduate attributes; identified high-priority professional/clinical attributes and curriculum gaps.	Desirable non-technical attributes and professionalism Secondary Domain: Scope of practice
Perona et al.	2019	Australia	Narrative literature review	Narrative synthesis of paramedic reasoning/decision-making; highlighted lack of global standardization and role variation.	Desirable non-technical attributes and professionalism Secondary Domain: Scope of practice
Shields & Flin	2013	United Kingdom	Narrative review	Reviewed paramedic non-technical skills; argued for behavioral taxonomies and rating systems (CRM domains).	Desirable non-technical attributes and professionalism
Tavares et al.	2016	Canada	Mixed-methods study	Mixed-methods derivation of Canadian paramedic roles; highlighted cross-cutting capabilities (e.g., safety, adaptability).	Desirable non-technical attributes and professionalism Secondary Domain: Scope of practice
Williams et al.	2010	Australia	Exploratory factor analysis	EFA of graduate attributes; identified key professionalism, reasoning and self-development factors for entry-level practice.	Desirable non-technical attributes and professionalism
Batt et al.	2025	Canada	Competency framework development	Developed a contemporary national competency framework for Canadian paramedics using a systems-informed, six-step development model and multiple qualitative and quantitative methods.	Scope of practice Secondary Domain: Assessment of competency

Table 2. Characteristics of included studies.

Author	Year	Country	Methods	Key Contribution	Domain(s)
Batt et al.	2024	Canada	Systems-thinking study	Mapped multi-level influences on practice to strengthen competency framework development and contextual fit.	Scope of practice
Bolster et al.	2022	Canada	Restricted literature review	Synthesized emerging competency-relevant concepts (e.g., equity, adaptive expertise, virtual care) to inform future frameworks.	Scope of practice
Weber et al.	2024b	Australia	Narrative literature review	Identified themes within professional capabilities; highlighted high-priority domains and gaps (e.g., self-directed practice).	Scope of practice
Bigham et al.	2013	Canada	Systematic review	Community paramedicine research to date is lacking, but programs in the United Kingdom, Australia, and Canada are perceived to be promising.	Scope of practice
Clements & Mackenzie	2005	United Kingdom	Review	Applied the UK CFEC to paramedics to support role definition, training design, and workforce development.	Scope of practice Secondary Domain: Assessment of competency
von Vopelius-Feldt & Benger	2014	United Kingdom	Data triangulation study	Triangulated tasks/competencies across provider levels; informs scope definition and training for critical care practice.	Scope of practice
Salisbury et al.	2024	Canada	Survey-based study	Compared placement models; community placements supported competency achievement and may mitigate preceptor shortages.	Assessment of competency
Smith et al.	2020	Australia	Mixed-methods study	Evaluated APCAT placement tool; supported usability/alignment but identified need for assessor education and validation.	Assessment of competency
Smith et al.	2023	Australia	Grounded-theory study	Grounded theory of assessor judgements; highlighted context dependence and threats to reliability/validity of decisions.	Assessment of competency
Tavares & Boet	2016	Canada	Narrative review	Assessment theory synthesis proposing principles for defensible performance-based assessment and a paramedicine research agenda.	Assessment of competency

Table 2 (continued). Characteristics of included studies.

The most frequently cited paramedic competencies were consistently framed around the ability to think critically and make decisions, work independently and as a team, perform clinical skills, provide leadership and supervision, perform assessments (history taking and physical examination), adhere to ethical and legal practice, communicate effectively, demonstrate professionalism and trustworthiness, self-direct ongoing professional development, and integrate evidence-informed practice (AlShammari et al., 2018, 2019a, 2019b; Chang et al., 2018; Kilner, 2004; Tavares et al., 2016; Williams et al., 2010). More recent studies extended these competency expectations by explicitly incorporating systems thinking, evolving contexts of practice (e.g., community and non-traditional settings), and broader professional roles beyond emergency response (e.g., education, leadership, policy, public health, and research) (Batt et al., 2024, 2025; Bolster et al., 2022; Weber et al., 2024b).

Several included articles noted a transition in paramedic practice, shifting from technical skills used for treating life-threatening conditions, to a more holistic practice caring for a large variety of non-life-threatening conditions (Bigham et al., 2013; Clements & Mackenzie, 2005; Perona et al., 2019; Tavares et al., 2016). This transition was also reflected in newer Canadian and Australasian contributions describing contemporary roles and competencies that extend across emergency/primary care, community and system-facing

domains, and that emphasize context, equity, and adaptability alongside clinical competence (Batt et al., 2024, 2025; Bolster et al., 2022; Weber et al., 2024a). Changes in paramedic practice were also accompanied by increasing emphasis on university-based education and preparation for independent professional practice (Kilner, 2004; Tavares et al., 2016; Williams et al., 2010; Weber et al., 2024b). A trend is noted away from technical career training and moving towards university and higher education-based degree programs, thereby developing professionals who practice independently. Recent work also highlighted implications for competency achievement in alternative clinical placement models and persistent challenges in the reliability, validity, and consistency of competency assessment decisions (Salisbury et al., 2024; Smith et al., 2020, 2023; Tavares & Boet, 2016). In addition to summary characteristics, common themes were identified pertaining to paramedic competency among the included articles. Three domains emerged:

- Desirable non-technical attributes and professionalism;
- Scope of practice;
- Assessment of competency.

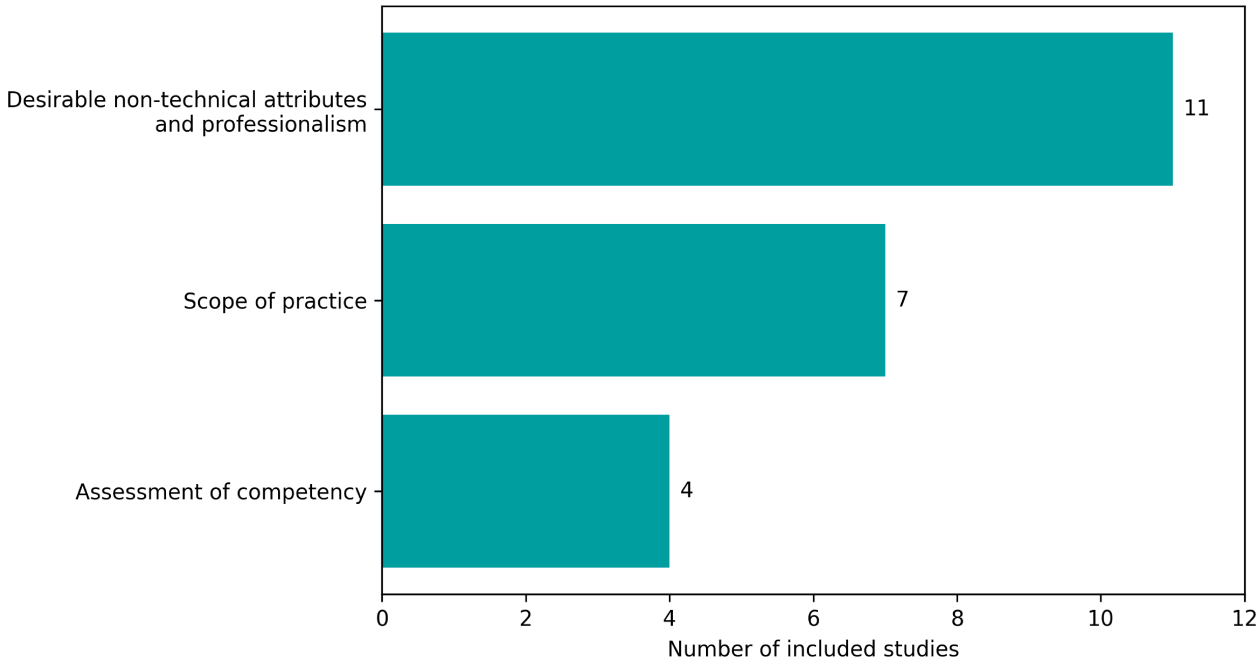


Figure 2. Frequency of primary competency domains across included studies (*n*=22).
Note: Frequency represents the primary domain assigned to each included study in Table 2; secondary domains are not included in these counts.

Desirable Non-Technical Attributes and Professionalism

Eleven studies examined non-technical and professional attributes expected of entry-level paramedics (AlShammari et al., 2018, 2019a, 2019b; Bennett et al., 2021; Chang et al., 2018; Cooper, 2005; Kilner, 2004; Perona et al., 2019; Shields & Flin, 2013; Tavares et al., 2016; Williams et al., 2010). Commonly identified attributes included ethical practice, professionalism, accountability, cultural sensitivity, communication, empathy, and responsibility for safe, high-quality care, alongside teamwork, leadership, situational awareness, and decision-making.

Several studies noted that non-technical skills had historically received limited curricular emphasis. Kilner (2004) highlighted gaps between highly rated attributes and existing curricula, while Williams et al. (2010) argued for empirically derived graduate attributes embedded within national standards, accreditation processes, and fitness-to-practice frameworks to support benchmarking and standardization.

Teamwork and leadership were also prominent non-technical competencies across the included literature. Serving as team members and team leaders was emphasized and explored in depth by Shields and Flin (2013), who identified seven papers focusing on elements of crew resource management, a communication and teamwork methodology that has been shown to reduce errors in aviation and health care (Shields & Flin, 2013; Verbeek-van Noord et al., 2015). Shields and Flin found that teamwork, leadership, situational awareness, decision making, and communication were encountered most frequently (Shields & Flin, 2013).

Williams et al. (2010) identified professionalism, clinical competence, communication, personal management, and self-directed learning as key graduate attributes for entry-level paramedics. Tavares et al. (2016) similarly noted that paramedics are social advocates for patients who practice in varied contexts as reflective and autonomous practitioners engaged in life-long learning. Continuing professional development, self-direction, and inter-professional communication were identified across six studies (AlShammari et al., 2019a, 2019b; Chang et al., 2018; Cooper, 2005; Kilner, 2004; Williams et al, 2010). Additionally, Chang et al. (2018) reported that training, licensing, working conditions, remuneration, and scope of practice were perceived as influencing professional performance.

Scope of Practice

Seven articles addressed scope of practice (Batt et al., 2024, 2025; Bigham et al., 2013; Bolster et al., 2022; Clements & Mackenzie, 2005; von Vopelius-Feldt & Benger, 2014; Weber et al., 2024a). Paramedics may be certified, licensed, registered, or credentialed at different levels according to jurisdictional requirements, responsibilities, and defined scope of practice. Scope may be shaped by permitted procedures, educational preparation, registration or certification requirements, and additional specialized competencies, as reflected in models across Taiwan, Canada, Ireland, Australia, the United Kingdom, and the United States (Chang et al., 2018; Health & Care Professions Council, 2023; National Association of State EMS Officials, 2021; Paramedic Association of Canada, 2024; Paramedicine Board of Australia, 2020; Pre-Hospital Emergency Care Council, 2026).

The definition of a paramedic has expanded to include assessment, treatment, and referral of non-emergent conditions, with the emergence of community paramedicine and mobile integrated health care (Ulintz et al., 2024; Williams et al., 2021). Bigham et al. (2013) reported that 30–50% of ambulance transports may be avoidable and described advances in alternative disposition pathways and roles in health promotion and injury prevention, themes echoed in subsequent work (AlShammari et al., 2019b; Chang et al., 2018; Tavares et al., 2016; Williams et al., 2021). More recent studies further characterize evolving paramedic roles in relation to professional capabilities, regulatory reform, accreditation expectations, and broader system-facing responsibilities across jurisdictions (Batt et al., 2024, 2025; Bolster et al., 2022; Ulintz et al., 2025; Weber et al., 2024a).

Assessment of Competency

Four articles primarily addressed assessment of competency: Tavares and Boet (2016), Salisbury et al. (2024), and Smith et al. (2020, 2023). Together, these studies examined performance-based assessment, clinical placement assessment, assessment tools, and assessor decision-making in entry-to-practice contexts. Tavares and Boet (2016) reviewed theoretically informed approaches to performance-based assessment in paramedicine. They conceptualized competence as developing across knowledge, skills and abilities, and argued that assessment should discriminate between levels of performance, support defensible achievement decisions and provide meaningful evidence about future clinical performance in new contexts. They also noted the limited paramedic-specific evidence base, with much of the available research focused on isolated technical or non-technical skills or specific patient populations.

Tavares and Boet (2016) also discussed Miller's pyramid, which conceptualizes assessment across four levels: "knows," "knows how," "shows how," and "does". They argued that competence is best assessed in contexts that approximate the settings in which future clinical performance is expected. Rather than relying on a single assessment method, their review emphasized multiple observations and sources of evidence to improve the accuracy and defensibility of decisions about competence.

The conceptual and theoretical approaches discussed by Tavares and Boet (2016), including Miller's pyramid, Kane's conceptualization of competence, generalizability and reliability, validity, and multiple sampling—provide a basis for strengthening summative entry-to-practice assessment in paramedicine. They also identified emerging areas including programmatic assessment, the appropriate use of assessor judgment and narrative information, and a better understanding of how raters make decisions. Recent included studies extend these concerns by emphasizing assessor judgment, the context dependence of competence decisions, and the need for defensible assessment systems that support consistent decisions across varied placement environments (Salisbury et al., 2024; Smith et al., 2020, 2023).

DISCUSSION

This scoping review synthesized 22 publications to clarify how entry-level paramedic competence has been conceptualized, operationalized, and assessed across diverse international contexts. Competency-based education requires a comprehensive description of the abilities needed to enter a profession (Frank, 2005; Frank et al., 2010). Given the changes underway in paramedicine internationally, an updated synthesis of the evidence informing entry-level paramedic competency is warranted. Across the included studies, three domains emerged: desirable non-technical attributes and professionalism; scope of practice; and assessment of competency.

Notably, attributes that would appear fundamental to paramedic practice were not universally articulated. For example, AlShammari et al. (2019a) identified coping skills in stressful situations as a core competency; however, coping and resilience were infrequently operationalized across other studies, despite the high-acuity and unpredictable environments in which paramedics practice (National EMS Management Association, 2017). Similarly, domains such as communication, accountability, record keeping, and ongoing professional development were variably represented across frameworks and

studies (Kilner, 2004; Williams et al., 2010). In the updated literature, non-technical professionalism and adaptability remained prominent, but the inconsistent specification of wellbeing, coping, and resilience suggests persistent gaps in how frameworks define and justify "core" entry-level requirements (AlShammari et al., 2019b).

Variation was also observed even where study designs were similar. Both Chang et al. (2018) and AlShammari et al. (2019b) used factor analytic approaches grounded in earlier empirically derived attributes (Kilner, 2004; Williams et al., 2010), yet their "top" competency factors differed in emphasis. Chang et al. (2018) prioritized clinical competence and professionalism, patient-centered practice, continuing professional development, self-management and safety, and clinical reasoning; AlShammari et al. (2019b) emphasized effective clinical care, professional and legal boundaries, safety procedures, respectful practice, and teamwork. Such differences likely reflect local educational pathways, regulation and credentialing expectations, and service models, and reinforce the importance of contextualizing competency profiles rather than assuming universal equivalence (Batt et al., 2024, 2025). Temporal context is also important. Earlier studies captured paramedicine during periods of considerable educational and professional transition, whereas more recent literature increasingly reflects degree-based preparation, professional regulation, and capability-based standards. Accordingly, similarities across studies should not be interpreted as evidence that entry-to-practice expectations, regulatory structures, or workforce models have remained unchanged over time. At the same time, there is increasing convergence at the level of high-order domains: professionalism, communication, clinical reasoning, patient assessment, and teamwork, even where operational detail differs across jurisdictions (Perona et al., 2019). Jurisdictional context similarly limits direct comparison. The included studies represent different health systems, educational pathways, credentialing arrangements, and stages of professional regulation, ranging from registered professional workforces to systems with more varied credentialing pathways. Consequently, terms such as entry-level, independent practice, and scope of practice may represent different expectations across jurisdictions. The findings should therefore be interpreted as mapping common and divergent entry-to-practice expectations rather than defining equivalent professional roles internationally.

This pattern aligns with broader critiques of competency framework development. Batt et al. (2020) identified substantial variability in how frameworks are constructed, raising concerns about their validity and utility when derived predominantly from local expert consensus processes without robust empirical triangulation. The present review supports this concern, with newly included studies demonstrating continued differences in how competency domains are defined, derived, and mapped to regulatory or accreditation requirements (Batt et al., 2025; Bolster et al., 2022; Weber et al., 2024b). Collectively, the evidence suggests partial alignment in high-level expectations but continued absence of a globally standardized, empirically unified entry-level competency framework for paramedicine (Perona et al., 2019). Professional regulation also changes how entry-to-practice expectations are operationalized. In regulated systems, professional capabilities or standards inform curriculum accreditation and expectations for registration, rather than functioning simply as lists of discrete competencies. This distinction is important when comparing studies across jurisdictions, particularly where educational preparation, credentialing and regulatory oversight differ.

Teamwork and team leadership were prominent across included studies and are central to paramedic practice, particularly as roles expand into more complex, system-facing models of care (Shields & Flin, 2013). Although some relevant teamwork/crew resource management work was excluded because of its focus on a single competency domain, it reinforces the need for clearer specification and assessment of teamwork, communication, situational awareness, and leadership behaviors (Shields & Flin, 2013). As paramedicine increasingly interfaces with multidisciplinary care pathways, these domains warrant explicit articulation and defensible assessment, rather than implicit assumptions that they are embedded within broader constructs such as "professionalism" or "critical thinking" (Shields & Flin, 2013).

Assessment remains a key challenge for competency-based education implementation in paramedicine. A lack of consensus on standards for assessing competence has been reported internationally (Michau et al., 2009; O'Meara et al., 2014, 2015; Westgard et al., 2013; Williams & Teese, 2016). One-off evaluations often under simulated or constrained conditions may not translate to consistent real-world performance (Tavares & Boet, 2016). The broader assessment literature emphasizes that defensible decisions require appropriate sampling and multiple observations across contexts, and that competence is a temporary state requiring ongoing maintenance (Epstein & Hundert, 2002; Tavares & Boet, 2016). These concerns are amplified in out-of-hospital care where settings, patient presentations, volumes, and acuity vary widely, complicating reliable workplace-based assessment (Crossley & Jolly, 2012). The evidence reinforces that assessor judgments and placement-based decisions are highly context dependent, supporting the need for clear standards, rater development, and repeated observation across placements and clinical contexts to underpin defensible entry-to-practice decisions (McAllister et al., 2025; Tavares & Boet, 2016).

Other regulated health professions have addressed similar issues using profession-specific workplace assessment tools linked to professional standards or capabilities. Examples include the Assessment of Physiotherapy Practice (APP), Australian Nursing Standards Assessment Tool (ANSAT), Australian Midwifery Standards Assessment Tool (AMSAT), and Competency Assessment in Speech Pathology (COMPASS) (Dalton et al., 2011; McAllister et al., 2010; Ossenberg et al., 2016; Sweet et al., 2020). These tools show how professional standards can be translated into structured assessment in practice and may offer useful guidance for paramedicine.

Finally, while non-technical competence was strongly represented, clinical competence remained essential across included studies. Nevertheless, the literature rarely provided comprehensive lists of clinical tasks or interventions, and there was limited linkage between entry-to-practice standards and procedures with demonstrated outcome impact (Batt et al., 2025; Weber et al., 2024b). Given contemporary scope expansion and increasing expectations for autonomous decision making, stronger integration is needed between high-impact clinical interventions, broader competency domains (e.g., assessment and reasoning), and assessment strategies (Batt et al., 2025; Weber et al., 2024b). Without clearer empirical linkage, educators and regulators risk maintaining entry standards that are either reductionist or insufficiently aligned with contemporary prehospital practice (Batt et al., 2024).

Future Directions

Two areas warrant further research: how entry-to-practice expectations are defined across different regulatory and educational systems, and how readiness for independent practice should be assessed. Recent studies have added to the evidence on assessor judgment and workplace-based assessment, but well-validated approaches remain limited. Future work should compare where jurisdiction-specific standards and capabilities align or differ, rather than pursue a single universal framework. Assessment studies should also examine reliability, validity, and feasibility across placement models, including how much evidence is needed, from what settings, and with what level of assessor preparation.

Limitations

Despite attempts to be comprehensive, not all relevant studies may have been identified. While a validated paramedic search filter was utilized, the terms paramedic and paramedicine do not have a standardized international nomenclature. Some countries utilize specialized nurses, physicians, or other practitioners with similar training, scope, and competency profiles. For example, Dutch and Brazilian studies employing methods similar to those of Chang et al. (2018) and AlShammari et al. (2019b) described competencies for ambulance nurses (Gentil et al., 2008; Van Schuppen & Bierens, 2011). These articles were excluded because they did not specifically name paramedics, although the findings were broadly consistent with this review. As formal critical appraisal was not undertaken, this review does not determine the methodological robustness of individual studies or weight findings according to study quality.

Although gray literature searching was undertaken, sources such as Google Scholar have inherent reproducibility limitations, and some relevant documents may not be consistently retrievable across time or users (Rethlefsen et al., 2021). Moreover, limited reporting in some studies restricted detailed synthesis. For example, von Vopelius-Feldt and Benger (2014) listed 389 distinct skills identified through direct observation; however, the complete list was not published and could not be included. Finally, heterogeneity in methodologies and contextual differences between countries may affect generalizability and complicate direct comparison, particularly where competence was conceptualized as discrete competencies, broader capability domains, scope-of-practice expectations, or assessment decision processes. The broad publication period also spans substantial changes in paramedic education and regulation; consequently, findings from earlier studies may not fully reflect contemporary entry-to-practice expectations in regulated professional systems.

CONCLUSION

This scoping review identified three domains in the expected competency of entry-level paramedics: desirable non-technical attributes and professionalism; scope of practice; and assessment of competency. Future research should examine how jurisdiction-specific entry-to-practice standards and capabilities can be translated into assessment approaches that are measurable, feasible, and defensible within their educational, regulatory, and clinical contexts.

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REVIEWS

STAKEHOLDER ACCEPTANCE OF DRONES IN PREHOSPITAL EMERGENCY CARE: AN INTEGRATIVE REVIEW

Grant Colvin, BSN, RN*[1,2]

Author Affiliations: 1. School of Nursing, University of Kansas Medical Center (KUMC), Kansas City, KS, USA; 2. General Internal Medicine, University of Kansas Health System, Kansas City, KS, USA.

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**Corresponding Author:* gcolvin@kumc.edu

ABSTRACT

Objectives: Drones are increasingly examined as tools to strengthen prehospital emergency care through rapid supply delivery, improved scene access, and situational support. Successful integration depends not only on technical performance, but on how drones are perceived by clinicians, telecommunicators, bystanders, patients, and communities. This integrative review, informed by the Technology Acceptance Model (TAM), synthesized empirical evidence on stakeholder perspectives regarding drone integration in prehospital emergency care to identify perceived benefits, concerns, and implications for practice and policy.

Methods: Five databases were searched in November 2025: CINAHL, PubMed, Web of Science, Embase, and Google Scholar. English-language peer-reviewed studies from the previous 10 years were included if they examined stakeholder perceptions of drones in prehospital or emergency contexts. Studies without perceptual data or unrelated to prehospital care were excluded. Included studies were appraised using the Mixed Methods Appraisal Tool (MMAT) and synthesized thematically.

Results: Eighteen empirical studies were included, reflecting perspectives of bystanders, health care professionals, telecommunicators, patients, and community members. Five themes emerged: perceived value and acceptance; safety and ethical concerns; usability experiences; operational feasibility and system readiness; and training needs. Perceived usefulness was the strongest driver of acceptance; perceived ease of use was more variable and shaped by communication, preparation, and contextual readiness.

Conclusions: Drone adoption in prehospital emergency care requires human and organizational readiness alongside technical capability. Implementation should prioritize drone-integrated workflows, telecommunicator and community training, and equitable deployment planning.

BACKGROUND

Drones, or unmanned aerial vehicles (UAVs), are increasingly being explored as tools to improve prehospital emergency response. Their advantage lies in their capacity for rapid deployment, relative independence from road traffic, and potential to shorten the delay between the onset of a medical emergency and the arrival of emergency medical services (EMS) (Claesson et al., 2017; Roberts et al., 2023). In this review, prehospital emergency care refers to the assessment and initial treatment of acute med-

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ical conditions before or during transport to a hospital, involving EMS personnel, telecommunication coordination, and often lay bystander participation.

The clinical urgency is considerable. Out-of-hospital cardiac arrest (OHCA) affects more than 350,000 people annually in the United States, and survival to hospital discharge for adult EMS-treated nontraumatic OHCA remains approximately 9.1% (Martin et al., 2025). Time to defibrillation is especially consequential: Virani et al. (2020) reported that nearly 60% of patients defibrillated within two minutes survived, compared with 13.2% of those defibrillated within 10 minutes.

Drones have shown promise as one strategy to reduce this delay. Claesson et al. (2017) found that autonomous drones arrived faster than EMS in all tested cases during a simulated AED delivery study. By the mid-2020s, drone-enabled AED delivery had moved from simulation into real-world dispatch studies and pilot implementation, particularly in Sweden, though routine large-scale integration remains limited (Schierbeck et al., 2022; Smith et al., 2025; Zègre-Hemsey et al., 2024).

Successful integration, however, depends on more than technical performance. End-user reactions, trust, usability, and workflow fit shape whether a technology is meaningfully adopted. This concern is especially salient in prehospital contexts, where drone interventions may depend on telecommunicators, clinicians, or lay responders making rapid decisions under acute stress with limited prior training.

Existing reviews have not fully addressed this stakeholder-centered question. Roberts et al. (2023) emphasized operational potential and time-to-intervention more than stakeholder perceptions. Stephan et al. (2022) focused narrowly on user interaction in experimental OHCA studies. Sanz-Martos et al. (2022) summarized applications and feasibility without centering acceptance across stakeholder groups. The present review addresses this gap by synthesizing how health care professionals, telecommunicators, bystanders, patients, and community members perceive the value, usability, risks, and acceptability of drone integration across prehospital emergency settings. Based on the prior review literature identified, this appears to be the first integrative review to synthesize perspectives across all five of these stakeholder groups and one of the first to interpret findings through the Technology Acceptance Model.

THEORETICAL FRAMEWORK

This review was informed by the Technology Acceptance Model (TAM) (Davis, 1989). TAM proposes that technology acceptance is shaped primarily by perceived usefulness, or the extent to which a system is believed to enhance performance, and perceived ease of use, or the extent to which the system is perceived as free of effort. These perceptions influence attitudes toward use, behavioral intention, and eventual adoption.

TAM informed the construction of the review question, search strategy, and data extraction domains. Thematic coding proceeded inductively, and resulting themes were subsequently interpreted in relation to TAM constructs: perceived value and acceptance align most closely with perceived usefulness, while usability experiences correspond to perceived ease of use. Training needs, operational readiness, and safety and ethical concerns reflect contextual influences shaping both.

TAM has recognized limitations in health care contexts. It does not fully account for organizational constraints, clinical complexity, or involuntary adoption. Related frameworks including Normalization Process Theory and Diffusion of Innovations may better capture implementation dynamics. In this review, TAM is useful for understanding judgments of value and usability but insufficient to explain the full regulatory, ethical, and sociopolitical complexity of drone integration.

PURPOSE STATEMENT

The purpose of this integrative review is to synthesize the existing literature on stakeholder perspectives regarding drone integration in prehospital emergency care. Specifically, this review aims to (1) describe how health care professionals, telecommunicators, bystanders, patients, and community members understand, value, and experience drone use across prehospital emergency applications; (2) identify common and context-specific perceived benefits, concerns, and influences on acceptance; and (3) outline implications for practice, policy, and future research. This review sought to answer: How do stakeholders across prehospital emergency care contexts perceive the value, usability, safety, and acceptability of drone integration?

METHODS

Design

This review used integrative review methodology to synthesize primary empirical evidence across multiple methodological traditions (Whittemore & Knafl, 2005). A predefined review protocol was developed before screening and data extraction to guide search, eligibility, selection, extraction, appraisal, and thematic synthesis procedures. The protocol was not prospectively registered in PROSPERO—a limitation that reduces external transparency—but was applied consistently throughout to improve rigor. Review reporting was informed by PRISMA 2020 guidance (Page et al., 2021).

Search Strategy

A systematic literature search was conducted in November 2025 across CINAHL, PubMed, Web of Science, Embase, and Google Scholar. Search terms were organized into three conceptual domains: drone terminology (e.g., "drone," "UAV," "UAS"), prehospital and emergency terminology (e.g., "prehospital," "EMS," "triage," "search and rescue"), and perception terminology (e.g., "perception," "attitude," "acceptance," "trust"). Domains were combined using Boolean operators, truncation, and database-specific controlled vocabulary including MeSH terms. Full search strings are provided in Appendix A. The search was limited to English-language, peer-reviewed publications from the past 10 years. Grey literature, dissertations, and preprints were excluded. In Google Scholar, the first 200 results were eligible for screening per protocol. The Google Scholar search returned 166 results, all of which were screened. No published, validated search filters were applied; the search strategy was developed de novo for this review, with each database string constructed independently using database-specific controlled vocabulary and syntax. The search strategy was developed in consultation with a health sciences librarian, who reviewed the search terms and database syntax during development. A formal peer-review instrument was not used.

Eligibility Criteria

Eligibility criteria were informed by the SPIDER framework (Cooke et al., 2012), encompassing: Sample (nurses, paramedics, clinicians, telecommunicators, patients, bystanders, and community members); Phenomenon of Interest (drone use in prehospital, disaster, search-and-rescue, and emergency contexts); Design (qualitative, quantitative descriptive, and mixed-methods studies); and Evaluation (stakeholder-reported perceptions or experiences of drone use).

Studies were included if they were published in English within the previous 10 years, examined stakeholder perceptions of drones in prehospital or emergency contexts, used qualitative, quantitative descriptive, or mixed-methods designs, and addressed medical drone applications such as AED delivery, medication delivery, scene assessment, triage, or search-and-rescue. Studies were excluded if they focused on engineering or technical performance without perceptual data, investigated drone applications unrelated to prehospital emergency care, or were not full-text, peer-reviewed English-language articles within the specified date range.

Study Selection

All search results were imported into EndNote for deduplication and uploaded into Covidence for secondary deduplication and screening. Study selection occurred in two stages: title and abstract screening, followed by full-text review. Screening was conducted by one reviewer using the predefined eligibility criteria. Because dual independent screening was not performed, the review carries increased risk of selection bias. Reasons for exclusion at the full-text stage were recorded. The study selection process is reported using a PRISMA flow diagram (Figure 1).

Data Extraction

A standardized extraction form in Covidence was used to collect citation information, study setting, participant groups, sample size, study aim, drone application, study design, theoretical framework, key findings related to stakeholder perceptions, strengths and limitations, and funding source. Extracted data were organized into a study characteristics matrix summarized in Table 1.

Quality Appraisal

Included studies were appraised using the Mixed Methods Appraisal Tool (MMAT) version 2018, which provides design-specific quality criteria applicable to qualitative, quantitative, and mixed-methods studies (Hong et al., 2018). Appraisal was conducted by one reviewer. Results are presented in Appendix B.

Thematic Synthesis

Data synthesis followed thematic synthesis methods informed by Thomas and Harden (2008). Key perception-related findings were extracted verbatim, grouped into descriptive codes, and progressively consolidated into analytic themes. Coding proceeded inductively without predetermined categories. Resulting themes were subsequently interpreted in relation to TAM constructs.

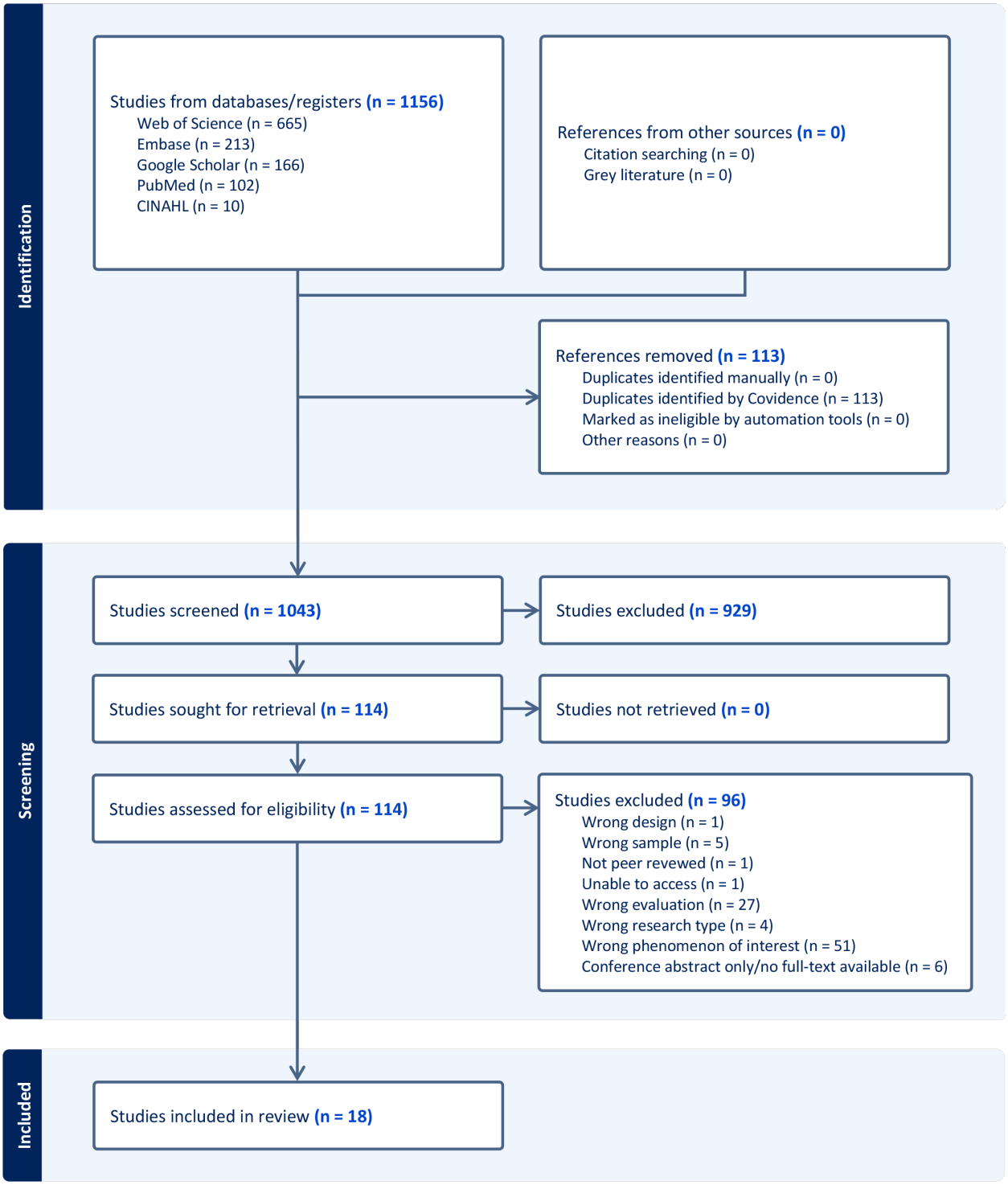


Figure 1. PRISMA flow diagram.

Author/ Year	Country	Design	Population/ Sample	Sample Size	Drone Application	Key Perception-Related Findings
Bernstein et al., 2025	UK	Qualitative interview study	Real-life OHCA bystanders	14	Drone-delivered AED for OHCA	Bystanders generally accepted drone-delivered AEDs in principle but were uncertain about effectiveness, retrieval, and use under stress. Low AED literacy was prominent. Participants suggested training, regulation, visibility/access improvements, call-handler scripts, and co-responder support.
Fink et al., 2023	Germany	Qualitative focus-group study	Patients, pharmacists, physicians, and nurses	36	Medical drone delivery of medicines	Participants viewed drones as useful for limited mobility, time-critical medication, emergencies, disasters, and rural delivery. Knowledge deficits and the need for education were recurring concerns.
Finney et al., 2025	UK	Qualitative study	Older adults interviewed	12	Drone-delivered AED for OHCA	Participants identified themes of human-drone interaction, societal benefit, and safety. Concerns focused more on AED use and leaving the patient than on the drone itself.
Dalby-Pedersen et al., 2024	Sweden	Qualitative phenomenological interview study	Registered nurses / dispatcher nurses	10	Drone-delivered AED for OHCA	Dispatcher nurses described variable protocol compliance, uncertainty about acceptable CPR interruption, and the importance of technical support, routines, and training.
Hartman et al., 2020	USA	Prospective simulation survey study	Conference attendees	44	Drone-assisted delivery of life-saving supplies during mass-casualty triage	Participants under-triaged overall, but confidence improved after the exercise. Most were initially unaware of drone use in mass-casualty incidents and rated drones as useful after the simulation.
Holzmann et al., 2021	Austria	Quantitative survey study	Mountain rescuers	146	Drones in mountain rescue missions	Behavioral intention to adopt drones was driven by performance expectancy and facilitating conditions. Previous drone experience strengthened adoption; effort expectancy and social influence were not significant.
Kim et al., 2021	South Korea	Mixed methods randomized simulation study	College students randomized to audio-only vs. video plus audio groups	24	Drone-delivered AED for OHCA	Video-assisted instruction improved CPR performance measures. Qualitative findings suggested that drone use felt unfamiliar but helpful, provided emotional support, and generated mixed views about the technology.
Mahmoud & Mahroof, 2025	Multi-country social media dataset	Mixed-methods big-data content analysis	Reddit and YouTube comments	2,337 cleaned comments from 6,403 scraped comments	Drone delivery in extreme contexts	Five themes emerged: safety/security, skepticism/distrust, ethical concerns, support for innovation/efficiency, and practicality/feasibility. Overall sentiment was slightly more negative than positive.
Ornato et al., 2020	USA	Quantitative simulation study	Waiting-room patients and visitors	30	Drone-delivered naloxone for opioid overdose	All participants successfully administered naloxone. Prior medical training and familiarity with nasal spray devices shortened delivery time.

Table 1. Characteristics of the 18 included studies.

Author/ Year	Country	Design	Population/ Sample	Sample Size	Drone Application	Key Perception-Related Findings
Rosamond et al., 2020	USA	Quantitative randomized simulation study	Bystanders at a public access site	50	Drone-delivered AED for OHCA	Participants who received drone delivery retrieved the AED and applied it more quickly than controls. Participants expressed high overall satisfaction and willingness to use the drone again.
Sanfridsson et al., 2019	Sweden	Mixed methods simulation study	Lay bystanders	23	Drone-delivered AED for OHCA	Participants generally had positive experiences. Key challenges included drone noise, uncertainty about approach, and time taken to retrieve the AED. Most preferred the drone over waiting for EMS.
Sedig et al., 2020	Canada	Qualitative interview study	Public community members	25	Drone-delivered AED for OHCA	Participants supported drone AED delivery but many had no AED literacy. Themes included public trust, the importance of guidance, and the value of community education campaigns.
Showalter et al., 2025	USA	Mixed methods simulation study	Nursing students	NR	Drone technology in obstetrical simulation	Simulation improved students' understanding of and readiness for technology-based care delivery. Students reported increased confidence and interest in drone-enabled care.
Smith et al., 2025	UK	Mixed methods simulation study	Bystander lay responders	53	Drone-delivered AED for OHCA	Participants successfully retrieved and applied AEDs. Common challenges included approach uncertainty and payload retrieval. Most supported ongoing drone AED programs.
Truog et al., 2020	Multi-country (Malawi, Mozambique, Democratic Republic of the Congo, Dominican Republic)	Qualitative community perception study	Rural community members and leaders	450	Medical drone delivery	Community acceptance was contingent on trust in the operating organization, understanding of drone purpose, and perception of community benefit. Distrust of external actors was a key barrier.
Wankmüller et al., 2021	Multi-country dataset (Austria, Italy)	Qualitative usability test study	Multi-disciplinary emergency responders	146	Drones in cross-border emergency response	Participants valued drone speed but identified key usability challenges in handoff coordination, airspace management, and role clarity across agencies.
Zègre-Hemsey et al., 2020	USA	Qualitative embedded simulation study	Lay bystanders	50	Drone-delivered AED for OHCA	Positive interaction with drone delivery; usability challenges included noise, approach uncertainty, and interruption to CPR. Communication from dispatchers was identified as a critical success factor.
Zhang et al., 2025	China	Quantitative descriptive survey study	Medical professionals	239	Drone delivery of medical supplies	High overall acceptance. Perceived usefulness, ease of use, and system reliability were significant predictors of acceptance. Older professionals and those in rural areas expressed stronger support.

Note. OHCA = out-of-hospital cardiac arrest; AED = automated external defibrillator; NR = not reported; UAV = unmanned aerial vehicle.

Table 1 (continued). Characteristics of the 18 included studies.

RESULTS

Study Characteristics

The database search yielded 1,156 records before deduplication: Web of Science (n = 665), Embase (n = 213), Google Scholar (n = 166), PubMed (n = 102), and CINAHL (n = 10). After the removal of 113 duplicate records, 1,043 records remained for screening. Following title and abstract screening and full-text review, 18 studies were included. Across the included studies, participants were drawn from 13 countries. Eight countries were represented by single-country studies (United States, United Kingdom, Sweden, Germany, South Korea, Canada, Austria, and China), and three used multi-country designs: one spanning Malawi, Mozambique, the Democratic Republic of the Congo, and the Dominican Republic; one spanning Austria and Italy; and one drawing on an international social media dataset. Designs included qualitative studies (n = 8), quantitative descriptive or simulation studies (n = 5), and mixed-methods studies (n = 5). Participants included health care professionals, telecommunicators, patients, community members, and bystanders. Study characteristics are presented in Table 1.

Quality Appraisal

MMAT appraisal indicated that most studies met quality criteria for their respective design categories. Four studies were rated as having moderate quality concern, primarily related to representativeness of sampling and non-random recruitment in quantitative descriptive designs. Fourteen studies were rated as lower or lower-to-moderate concern. Full appraisal results are provided in Appendix B.

Thematic Synthesis

Five themes emerged from the thematic synthesis: (1) perceived value and acceptance, (2) safety and ethical concerns, (3) usability experiences, (4) operational feasibility and system readiness, and (5) training needs.

Theme 1: Perceived Value and Acceptance. Across the evidence base, stakeholders generally viewed drones favorably when they were perceived as meaningfully improving access to time-sensitive care. Bystanders and community participants responded positively to drone delivery of AEDs for OHCA, particularly in settings where EMS response intervals were perceived as long (Bernstein et al., 2025; Finney et al., 2025; Rosamond et al., 2020; Sanfridsson et al., 2019; Smith et al., 2025; Zègre-Hemsey et al., 2020). Clinicians and telecommunicators expressed similar endorsement of drones for AED delivery, drug delivery, and situational support, particularly in rural or geographically challenging terrain (Fink et al., 2023; Hartman et al., 2020; Holzmann et al., 2021; Wankmüller et al., 2021). Health care professionals in a multicenter survey reported high intention to adopt drones for medical supply delivery, especially for urgent medications (Zhang et al., 2025). Participants who expressed initial skepticism frequently shifted toward positive appraisal following hands-on simulation or exposure to operational demonstrations (Hartman et al., 2020; Holzmann et al., 2021; Ornato et al., 2020).

Acceptance was not unconditional. A multi-country social media analysis found slightly more negative than positive public sentiment regarding drones in extreme delivery contexts, organized around themes of safety concern, ethical ambivalence, and skepticism

toward institutional accountability (Mahmoud & Mahroof, 2025). These findings suggest that general acceptance of drones as a concept does not translate automatically into willingness to use them in emergency care.

Theme 2: Safety and Ethical Concerns. Safety and ethical concerns were prominent across clinician, bystander, and community-facing studies. Recurring safety concerns included the risk of drone malfunction or collision during payload delivery, noise and disruption at the scene, uncertainty about drone approach trajectories, and the potential for interaction with bystanders or other responders (Fink et al., 2023; Finney et al., 2025; Kim et al., 2021; Mahmoud & Mahroof, 2025; Sanfridsson et al., 2019). In several qualitative studies, participants raised concerns about drone collision with structures or people and expressed uncertainty about what to do if the drone behaved unexpectedly (Bernstein et al., 2025; Sedig et al., 2020; Zègre-Hemsey et al., 2020).

Ethical concerns included privacy, surveillance, and symbolic associations of drones with military or policing functions. Community-facing studies reported that associations with surveillance technology created mistrust, particularly in settings with histories of community-police tension (Mahmoud & Mahroof, 2025; Truog et al., 2020). Participants also raised questions about accountability and data governance. These concerns were more salient in community and public-perception studies than in professional or clinical contexts.

Theme 3: Usability Experiences. Usability emerged as a critical and variable dimension of drone acceptance. Participants in simulation and field studies described specific challenges including difficulty locating and approaching a hovering drone, confusion about payload retrieval mechanisms, noise interference with telecommunicator communication, and cognitive overload when processing drone-related tasks alongside CPR (Bernstein et al., 2025; Sanfridsson et al., 2019; Kim et al., 2021; Zègre-Hemsey et al., 2020). Telecommunicator nurses described uncertainty about acceptable CPR interruption intervals and variable comfort with protocol-guided decision-making under time pressure (Dalby-Pedersen et al., 2024).

Importantly, usability was shaped not only by device design but by the communicative and situational context in which the drone was used. Participants who received clear, structured guidance from telecommunicators reported markedly better usability experiences than those who received limited or ambiguous direction (Bernstein et al., 2025; Kim et al., 2021; Zègre-Hemsey et al., 2020). These findings suggest that perceived ease of use is a property of the interaction system rather than the device alone.

Theme 4: Operational Feasibility and System Readiness. Several studies examined system-level factors influencing drone integration. Mountain rescue personnel endorsed drones for operational use but highlighted facilitating conditions such as adequate infrastructure, clear coordination protocols, and organizational support as prerequisites for adoption (Holzmann et al., 2021). Telecommunicator nurses described challenges related to protocol compliance, interagency coordination, and the need for clearly defined handoff procedures (Dalby-Pedersen et al., 2024). Community-level studies raised concerns about equitable deployment, noting that drones should be prioritized for rural, underserved, or infrastructure-limited communities where conventional response is most delayed (Truog et al., 2020; Zhang et al., 2025).

Studies also identified infrastructure and regulatory readiness as barriers. Participants raised concerns about airspace coordination, weather-dependent performance, liability in cases of drone failure, and the absence of standardized operational frameworks (Fink et al., 2023; Mahmoud & Mahroof, 2025; Wankmüller et al., 2021).

Theme 5: Training Needs. Training emerged consistently as a necessary condition for safe, acceptable, and effective drone use. Participants across clinical, telecommunicator, and bystander groups identified knowledge deficits regarding what the drone would look and sound like, when to approach, how to retrieve the payload, and how drone-related tasks should be prioritized alongside CPR (Bernstein et al., 2025; Dalby-Pedersen et al., 2024; Fink et al., 2023; Kim et al., 2021; Sanfridsson et al., 2019; Smith et al., 2025; Zègre-Hemsey et al., 2020). In several community-facing studies, participants demonstrated limited baseline CPR and AED confidence independent of the drone, suggesting that drone delivery may expose preexisting first-aid knowledge gaps (Finney et al., 2025; Sedig et al., 2020).

Educational and professional studies showed that hands-on exposure, simulation, and scenario-based preparation could improve confidence and readiness for drone-enabled care (Hartman et al., 2020; Holzmann et al., 2021; Wankmüller et al., 2021). Ornato et al. (2020) found that prior medical training shortened time to naloxone administration. Showalter et al. (2025) found that an obstetrical drone simulation improved students' understanding of and readiness for technology-based care delivery. Cross-context studies highlighted the value of public education and community demonstrations to reduce fear, build trust, and normalize the technology before real-world implementation (Mahmoud & Mahroof, 2025; Truog et al., 2020).

DISCUSSION

This integrative review synthesized 18 studies examining health care professional, telecommunicator, bystander, patient, and community member perspectives on drone use in prehospital emergency care. Drones were generally perceived as promising when understood as addressing a meaningful time-sensitive or logistical problem, particularly for AED access, naloxone delivery, and search-and-rescue. Acceptance, however, depended on whether drones were perceived as safe, usable, ethically legitimate, and compatible with existing emergency response systems.

These findings extend prior work in important ways. Roberts et al. (2023) focused on operational feasibility and time-to-intervention rather than stakeholder perceptions, and Sanz-Martos et al. (2022) summarized applications without centering acceptance across all five stakeholder groups. The present review integrates evidence from clinicians, telecommunicators, bystanders, and community members into a broader account of how drones are interpreted and operationalized across prehospital emergency contexts.

Interpretation Through the Technology Acceptance Model

The findings broadly support TAM, particularly the central role of perceived usefulness. Clinicians, telecommunicators, bystanders, and community participants described drones positively when they offered a clear functional advantage: more rapid AED access, faster medication delivery, or improved situational awareness in difficult terrain (Dalby-Pedersen et al., 2024; Hartman et al., 2020; Sanfridsson et al., 2019; Wankmüller et

al., 2021). This supports TAM's core proposition that technologies are more likely accepted when users believe they will improve task performance.

Perceived ease of use was less stable and more context dependent. Participants described uncertainty about drone approach and landing, difficulty retrieving the payload, interruption of CPR, and cognitive overload when processing telecommunicator instructions during high-acuity events (Bernstein et al., 2025; Holzmann et al., 2021; Sanfridsson et al., 2019). In OHCA studies, participants often expressed support for drone delivery while questioning whether they could retrieve and use the AED under pressure, suggesting a more dynamic conceptualization of perceived ease of use than TAM's original formulation allows.

The findings also illustrate TAM's limits. Concerns about privacy, surveillance, equity, and the symbolic association of drones with military or policing functions are not easily explained by perceived usefulness and ease of use alone. Community perceptions were shaped by who operated drones, trust in regulations, and perceived fairness (Mahmoud & Mahroof, 2025; Truog et al., 2020; Zhang et al., 2025). TAM illuminates judgments of value and usability but is insufficient to account for questions of justice, legitimacy, and public trust.

Patterns of Consensus and Divergence

Participants broadly agreed that drones can improve access to time-sensitive interventions, particularly where geography or limited infrastructure impedes conventional response. Hands-on interaction frequently transformed drones from abstract or intimidating technologies into more understandable clinical tools. The evidence also consistently showed that implementation success depends on telecommunicator communication, workflow fit, role clarity, and training.

The most consequential divergence was between health-system actors and community-facing participants. Clinicians, telecommunicators, and operational personnel evaluated drones primarily in terms of performance, speed, and protocol integration. Community members more often foregrounded privacy, fairness, trust, and broader social meaning. This divergence carries important implementation implications. Formal adoption decisions are typically driven by health care leaders and EMS systems, yet programs depend on bystanders and communities for practical success and social legitimacy.

This distinction is especially important for OHCA applications, where the bystander is an active and indispensable user. A drone-delivered AED is clinically meaningful only if the bystander can notice it, retrieve it, and use it under stress (Bernstein et al., 2025; Smith et al., 2025). Implementation strategies that prioritize operational efficiency while neglecting public trust and readiness may succeed administratively but fail practically.

Implications for Practice and Policy

Successful drone integration requires approaches addressing both operational and social barriers. Clinicians, telecommunicators, and emergency care professionals should serve not only as end users but as co-designers of drone-integrated systems. Evidence from telecommunicator studies shows that end-user involvement in workflow design, commu-

nication script development, and simulation testing can directly improve system readiness and safety (Dalby-Pedersen et al., 2024; Fink et al., 2023).

At the policy level, clearer regulatory and governance structures are needed. Participants raised concerns about safety oversight, privacy, accountability, and cross-agency coordination (Finney et al., 2025; Mahmoud & Mahroof, 2025; Truog et al., 2020). Drone programs should also be designed for interoperability, as response can be undermined by unclear communication pathways or poorly coordinated handoffs between telecommunicators, operators, and on-scene responders (Bernstein et al., 2025; Dalby-Pedersen et al., 2024; Smith et al., 2025).

Finally, the findings support a strong equity rationale for targeted implementation. Perceived value was greatest in settings where conventional EMS response is delayed by geography or resource constraints. Policymakers should prioritize rural, remote, and underserved communities for pilot investment, preceded by meaningful local engagement. Trust depends on communities understanding the purpose of drone use, approving of the actors involved, and perceiving the system as serving public benefit rather than being imposed without consultation (Truog et al., 2020).

Future Directions

Three priorities appear especially important. First, the field most urgently needs real-world, longitudinal, and implementation-focused research. Much current evidence derives from simulation, hypothetical scenarios, or early field testing. Future studies should examine how perceptions, trust, usability, and safety evolve as drone-enabled interventions move from pilot testing into routine practice.

Second, future research should focus on implementation design at the human-system interface. Participants rarely rejected drones outright; they identified uncertainty around handoff procedures, telecommunicator communication, payload retrieval, and role clarity. This suggests the need for intervention studies testing specific strategies such as revised telecommunicator scripts, user-centered payload design, and scenario-based training. Standardized measures of perceived usefulness, ease of use, trust, and readiness would also strengthen comparison across studies.

Third, future work should emphasize equity, context, and participatory design. Research is needed across rural and urban communities, varied sociocultural contexts, and populations with differing levels of emergency preparedness and institutional trust. Community-engaged approaches are especially valuable for ensuring that drone-enabled emergency care is designed with, not merely for, the populations it aims to serve.

STRENGTHS AND LIMITATIONS

This review appears to be the first to synthesize clinical, telecommunicator, bystander, and community perspectives on drone integration in prehospital emergency care, and one of the first to interpret findings through TAM. Strengths include an explicit theoretical lens, formal MMAT appraisal, and a diverse evidence base spanning qualitative, survey, simulation, and field evaluation designs.

These strengths must be weighed against important limitations. Screening, extraction, appraisal, and thematic coding were conducted by a single reviewer, increasing the risk

of selection and interpretive bias; the protocol was not prospectively registered. The evidence base was relatively small (18 studies) and weighted toward Western contexts, constraining transferability to settings with different health systems or sociopolitical relationships to drone technology. The search was restricted to English-language publications, and exclusion of grey literature may have introduced publication bias. Many included studies relied on small or convenience samples, and a substantial proportion used simulation-based designs that cannot fully reproduce real emergency conditions. Few studies examined long-term adoption or changes in community acceptance over time, and the literature offered limited attention to intersectional influences such as age, rurality, race and ethnicity, or health literacy.

CONCLUSIONS

This integrative review demonstrates that the central challenge in drone-enabled prehospital emergency care is not whether drones can outpace conventional response, but whether the systems surrounding them are trusted, usable, and ethically acceptable to the people expected to rely on them.

Across the evidence base, participants generally perceived drones as promising tools for improving access to time-sensitive emergency interventions. That promise was consistently moderated by concerns about usability, safety, privacy, fairness, workflow integration, and real-world readiness. The most important implication is that successful drone integration will depend on implementation centered on clinician, telecommunicator, bystander, and community needs rather than technical capability alone. The field's most urgent next step is not broader deployment, but deliberate, equitable co-design with the clinicians, bystanders, and communities whose trust will determine whether these systems save more lives.

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APPENDIX A

Database Search Strings

PubMed

("Drones"[MeSH] OR "Unmanned Aerial Vehicles"[MeSH] OR drone* OR "unmanned aerial vehicle*" OR UAV* OR UAS* OR "unmanned aircraft system*")

AND

("Emergency Medical Services"[MeSH] OR "Emergency Medicine"[MeSH] OR "Triage"[MeSH] OR "Disaster Planning"[MeSH] OR "Disaster Medicine"[MeSH] OR prehospital OR "pre-hospital" OR "prehospital care" OR "out-of-hospital" OR "field triage" OR "mass casualty incident*" OR MCI OR disaster* OR triage OR "search and rescue" OR "search-and-rescue" OR SAR OR EMS OR paramedic* OR clinician* OR nurse*)

AND

(perception* OR perspective* OR attitude* OR opinion* OR sentiment* OR experience* OR trust* OR concern* OR accepta*)

CINAHL (EBSCO)

((MH "Drones") OR (MH "Unmanned Aerial Vehicles") OR drone* OR "unmanned aerial vehicle*" OR UAV* OR UAS* OR "unmanned aircraft system*")

AND

((MH "Emergency Medical Services+") OR (MH "Emergency Medicine+") OR (MH "Emergency Nursing+") OR (MH "Prehospital Care") OR (MH "Triage") OR prehospital OR "pre-hospital" OR "prehospital care" OR "out-of-hospital" OR "mass casualty incident*" OR MCI OR disaster* OR triage OR "field triage" OR "search and rescue" OR "search-and-rescue" OR SAR OR EMS OR paramedic* OR nurse* OR clinician*)

AND

(perception* OR perspective* OR attitude* OR opinion* OR sentiment* OR experience* OR trust* OR concern* OR accepta*)

Web of Science

TS=((drone* OR "unmanned aerial vehicle*" OR UAV* OR UAS* OR "unmanned aircraft system*") AND (prehospital OR "pre-hospital" OR "prehospital care" OR "out-of-hospital" OR "emergency medical service*" OR EMS OR "mass casualty incident*" OR disaster* OR triage OR "field triage" OR "search and rescue" OR "search-and-rescue" OR SAR OR paramedic* OR clinician* OR nurse*) AND (perception* OR perspective* OR attitude* OR opinion* OR sentiment* OR experience* OR trust* OR concern* OR accepta*))

Embase

('drone'/exp OR 'unmanned aerial vehicle'/exp OR drone*:ti,ab,kw OR 'unmanned aerial vehicle*':ti,ab,kw OR uav*:ti,ab,kw OR uas*:ti,ab,kw OR 'unmanned aircraft system*':ti,ab,kw) AND ('emergency medical service'/exp OR 'emergency medicine'/exp OR

'prehospital care'/exp OR 'triage'/exp OR 'disaster medicine'/exp OR 'mass casualty incident'/exp OR prehospital:ti,ab,kw OR 'pre-hospital':ti,ab,kw OR 'out-of-hospital':ti,ab,kw OR 'field triage':ti,ab,kw OR 'mass casualty incident*':ti,ab,kw OR mci:ti,ab,kw OR disaster*:ti,ab,kw OR 'search and rescue':ti,ab,kw OR 'search-and-rescue':ti,ab,kw OR sar:ti,ab,kw OR ems:ti,ab,kw OR paramedic*:ti,ab,kw OR clinician*:ti,ab,kw OR nurse*:ti,ab,kw) AND (perception*:ti,ab,kw OR perspective*:ti,ab,kw OR attitude*:ti,ab,kw OR opinion*:ti,ab,kw OR sentiment*:ti,ab,kw OR experience*:ti,ab,kw OR trust*:ti,ab,kw OR concern*:ti,ab,kw OR accepta*:ti,ab,kw)

Google Scholar

With all of the words: prehospital "emergency medical services" EMS triage disaster "mass casualty" "search and rescue"

With at least one of the words: drone OR "unmanned aerial vehicle" OR UAV OR UAS OR "unmanned aircraft system" OR perception OR perceptions OR perspective OR perspectives OR attitude OR attitudes OR opinion OR opinions OR trust OR acceptability OR concern OR experience OR experiences

APPENDIX B

Mixed Methods Appraisal Tool (MMAT) Appraisal of Included Studies

Author/year	Study Design Category	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Overall Quality
Bernstein et al., 2025	Qualitative	Yes	Yes	Yes	Yes	Yes	Lower concern
Fink et al., 2023	Qualitative	Yes	Yes	Yes	Yes	Yes	Lower concern
Finney et al., 2025	Qualitative	Yes	Yes	Yes	Yes	Yes	Lower concern
Dalby-Pedersen et al., 2024	Qualitative	Yes	Yes	Yes	Yes	Yes	Lower concern
Hartman et al., 2020	Quantitative descriptive	Yes	No	Cannot tell	Yes	Yes	Moderate concern
Holzmann et al., 2021	Quantitative descriptive	Yes	Cannot tell	Yes	Yes	Yes	Lower-to-moderate concern
Kim et al., 2021	Mixed methods	Yes	Yes	Yes	Yes	Yes	Lower concern
Mahmoud & Mahroof, 2025	Mixed methods	Yes	Yes	Yes	Yes	Yes	Lower-to-moderate concern
Ornato et al., 2020	Quantitative descriptive	Yes	No	Yes	Yes	Yes	Moderate concern
Rosamond et al., 2020	Quantitative randomized	Yes	Cannot tell	Cannot tell	Yes	Yes	Moderate concern
Sanfridsson et al., 2019	Mixed methods	Yes	Yes	Yes	Yes	Yes	Lower concern
Sedig et al., 2020	Qualitative	Yes	Yes	Yes	Yes	Yes	Lower concern
Showalter et al., 2025	Mixed methods	Yes	Yes	Cannot tell	Yes	Yes	Lower-to-moderate concern
Smith et al., 2025	Mixed methods	Yes	Yes	Cannot tell	Yes	Yes	Lower-to-moderate concern
Truog et al., 2020	Qualitative	Yes	Yes	Yes	Yes	Yes	Lower concern
Wankmüller et al., 2021	Qualitative	Yes	Yes	Yes	Yes	Yes	Lower concern
Zègre-Hemsey et al., 2020	Qualitative	Yes	Yes	Yes	Yes	Yes	Lower concern
Zhang et al., 2025	Quantitative descriptive	Yes	No	Yes	Yes	Yes	Moderate concern

Note. Criteria 1-5 correspond to the design-specific MMAT items for each study category.

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REVIEWS

OCCUPATIONAL VIOLENCE IN PARAMEDICINE: AN INTEGRATIVE REVIEW OF PREVALENCE, PREDICTORS, MEASUREMENT GAPS, AND IMPACTS

Shohreh Majd, PhD, MSc, GCHE*[1,2]; Mojca Bizjak-Mikic[1]; Andrew Tombs[1]

Author Affiliations: 1. Council of Ambulance Authorities, Hilton, SA, Australia; 2. Flinders University, Bedford Park, SA, Australia.

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Keywords: ambulance, occupational violence, workplace aggression, prevalence, predictors, denominators, reporting, PTSD, burnout, emergency medical services, EMS, paramedicine

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**Corresponding Author:* przemyslaw.kluj@umed.lodz.pl

ABSTRACT

Background: Violence toward paramedics is a critical international occupational risk, undermining workforce safety, wellbeing, and system sustainability. Occupational violence (OV) includes verbal and psychological aggression, threats, physical assault, and harassment. The WHO identifies paramedics as a high-risk group, linking OV to physical and psychological harm and compromised care quality. Divergent definitions, variable recall windows, and under-documentation produce wide variation in reported prevalence.

Aim: To synthesize international and Australasian evidence on OV prevalence and typology in paramedicine; clarify how denominator choices and reporting behaviors shape observed rates; identify risk contexts and operational predictors; and examine consequences for clinicians, patients, and health systems.

Methods: A structured integrative review searched PubMed, Scopus, Web of Science, CINAHL, and Google Scholar (2000–2026), plus gray literature from WHO, ILO, Safe Work Australia, and national ambulance reports. Quantitative, qualitative, and mixed-methods studies of paramedics and EMS personnel from North America, Europe, Australasia, and selected Asian and Middle Eastern jurisdictions were included. Approximately 60 sources were narratively synthesized, addressing definitional variation, design heterogeneity, and denominator effects.

Results: Lifetime OV exposure among EMS personnel commonly exceeds 60%; 12-month prevalence ranges from 50% to 75%, depending on definitions and sampling. Administrative datasets under-capture incidents, particularly verbal abuse, intimidation, and identity-targeted aggression, whereas point-of-event reporting in electronic patient care records captures more. Violence is mostly patient-initiated, associated with intoxication, acute behavioral disturbance, mental health crises, urban settings, and weekend or night-time operations. Consequences include injury, post-traumatic stress disorder, burnout, emotional exhaustion, reduced therapeutic engagement, and turnover.

Conclusions: OV in paramedicine is common, patterned, and substantially under-documented. Observed prevalence is sensitive to definitions, recall period, and denominator choice, limiting unadjusted incident counts for benchmarking. Prevention and surveillance require standardized definitions, mission-based denominators, point-of-event reporting within clinical workflow, and paired leading and lagging indicators including reporting completeness.

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INTRODUCTION

Occupational violence (OV) toward health workers is a worldwide safety challenge. World Health Organization (WHO) identifies health workers as at high risk of violence worldwide, lists paramedics among higher-risk groups, and links violence exposure to physical and psychological harm, reduced job motivation, and compromised quality and continuity of care (World Health Organization, n.d.). The WHO/International Labour Organization (ILO) / International Council of Nurses (ICN) / Public Services International (PSI) Framework Guidelines similarly frame workplace violence in the health sector as a preventable occupational hazard. Such prevention requires coordinated action by employers, workers, and governments, underpinned by reliable data and prevention policies (International Labour Office et al., 2002).

Paramedics face distinct exposure because they deliver care in mobile, uncontrolled environments such as private homes, public spaces, vehicles, and crowded emergency departments (EDs), where security support, escape routes, and environmental controls are not guaranteed (McQueen et al., 2013; Reay et al., 2018). These settings intersect with frequent presentations involving intoxication, acute behavioral disturbance (ABD), delirium, mental health crises, grief, and pain. Operational pressures, dispatch uncertainty, incomplete information, delayed backup or co-response, and system bottlenecks, such as ambulance ramping and ED access block, further heighten the risk of violence (Bonumwezi et al., 2022; Lindridge et al., 2025).

The prehospital environment is closely intertwined with other pressured components of the emergency care system. Recent Australasian reporting on emergency department (ED) safety highlights how overcrowding, long wait times, and inconsistent access to trained security contribute to increasing levels of aggression (Australasian College for Emergency Medicine, 2025). These conditions heighten risks for paramedics during ED arrival and handover, particularly when delays extend or when teams are required to operate in congested triage or waiting areas. The report also notes that under-reporting of incidents remains a significant barrier to meaningful improvement. In parallel, contemporary violence-prevention standards emphasize strong governance, a positive reporting culture, effective data use, post-incident support and continuous quality improvement, offering a practical implementation benchmark for ambulance services and their partner organizations (NHS England, 2024).

Despite decades of observation and growing empirical work, progress in this field continues to be constrained by substantial measurement heterogeneity. Studies vary in what they classify as "violence," and survey designs differ widely in their recall periods, ranging from career-lifetime to twelve-month or three-month windows. Administrative datasets further under-capture many incidents, particularly verbal abuse, intimidation, and near-miss events, creating an incomplete picture of risk. Together, these inconsistencies hinder meaningful comparison across services and jurisdictions and can distort evaluation when incident counts are interpreted without consideration of reporting maturity. In this review, we examine the empirical landscape underpinning this problem, including definitional and denominator variation, heterogeneity in prevalence estimates, the persistent measurement gap, and the recurrent risk contexts and operational predictors identified across studies. We also consider the consequences for clinicians and

health-care systems, drawing together paramedicine-focused research alongside relevant high-authority guidance.

METHODS

This study adopted an integrative review design to synthesize the evidence on OV in paramedicine and emergency medical services (EMS), with a particular focus on prevalence, predictors, measurement limitations, and system-level impacts. An integrative approach was selected due to the methodological heterogeneity of the available literature, which includes quantitative, qualitative, mixed-methods, surveillance data, and policy reports. This approach enabled the inclusion and synthesis of diverse evidence types while preserving methodological distinctions between study designs. No primary data collection or expert interviews were conducted. The review relied solely on published peer-reviewed literature and authoritative gray literature sources. No contact was made with study authors for additional datasets.

A structured and transparent search strategy was developed to identify relevant literature across multiple sources. Electronic searches were conducted in PubMed (MEDLINE), Scopus, Web of Science, CINAHL, and Google Scholar. While primary searches were undertaken within these databases, Google Scholar was used to identify supplementary peer-reviewed studies and to capture interdisciplinary and emerging literature not yet fully indexed elsewhere. To ensure comprehensive coverage of operational and policy-relevant evidence, gray literature was also systematically searched, including publications from the WHO, the ILO, Safe Work Australia, and the National Health Service (NHS England), as well as publicly available reports from ambulance services across Australasian, North American, and European jurisdictions. These sources were included to address known limitations in academic reporting and to better reflect real-world operational surveillance systems. A broad search strategy was used due to heterogeneity in definitions and reporting systems in occupational violence research within paramedicine.

The search strategy combined controlled vocabulary and free-text keywords using Boolean operators to maximize sensitivity and capture variation in terminology across jurisdictions. Core terms included "occupational violence," "workplace violence," "assault," "aggression," and "abuse," combined with paramedicine and EMS terms such as "paramedic," "emergency medical services," "EMS," "prehospital," "ambulance," and "out-of-hospital care." Additional terms included "threats," "intimidation," "verbal abuse," "sexual harassment," and "near-miss," ensuring capture of both physical and non-physical forms of occupational violence. Search strings were adapted for each database to account for differences in indexing systems.

The literature search was conducted between June 7, 2025 and February 20, 2026, with the final search update completed on March 6, 2026. No artificial intelligence tools were used for literature searching, study selection, data extraction, or synthesis, and all processes were conducted manually by the authors.

The review was limited to studies published between 2000 and 2026 to reflect the period during which contemporary EMS systems, reporting infrastructures, and occupational violence frameworks have been developed and implemented. This timeframe ensured relevance to current paramedic practice and organizational reporting systems.

Studies were included if they examined occupational violence or workplace aggression in paramedicine or EMS settings and involved paramedics, emergency medical technicians, or other prehospital care providers. Eligible designs included quantitative, qualitative, mixed-methods, observational, surveillance, and systematic review studies. Only English-language publications were included. Studies were excluded if they focused exclusively on hospital inpatient settings, lacked empirical or synthesized data on occupational violence, or were purely opinion-based without substantive relevance.

Study selection followed a structured screening process. Titles and abstracts were first screened for relevance against inclusion criteria, followed by full-text review of eligible studies. Inclusion decisions were made by consensus among the authors to minimize selection bias. Included studies had already undergone peer review at the time of publication, and no additional peer-review process was applied within this integrative review. Approximately sixty peer-reviewed studies and authoritative sources were included.

Given heterogeneity in study designs and outcomes, data were synthesized using a narrative integrative approach. Findings were organized thematically across prevalence and measurement approaches, predictive and contextual risk factors, reporting and surveillance limitations, and consequences for clinicians, patients, and health systems. This approach enabled integration of diverse evidence while maintaining clarity across methodological differences.

A PRISMA flow diagram was not used due to the integrative design of the review; however, structured screening principles were applied throughout to ensure rigor, transparency, and reproducibility.

RESULTS

Definitions and Typology

Across the included evidence, OV is consistently described as a spectrum of behaviors ranging from verbal abuse and threats to intimidation, physical assault, and sexual harassment (Table 1).

Domain	Description	Key Sources
Core definition	Verbal abuse, threats, intimidation, physical assault, sexual harassment, sexual assault, and behaviors causing psychological harm toward workers	WHO; ILO/ICN/PSI
Expanded typology	Identity targeted abuse (sexist, racist, homophobic), near miss events, and behavioral precursors	Mausz et al.; Drew et al.
Physical violence	Hitting, kicking, biting, spitting, weapon use	Murray et al.; Shabanikiya et al.
Non physical violence	Verbal abuse, threats, intimidation, harassment	Bigham et al.; Sahebi et al.
Sexual violence	Sexual harassment and assault	Shabanikiya et al.; Sahebi et al.
Near miss events	Situations with credible threat or escalation potential without completed assault	IAFC Near Miss System; Murff et al.
Interactional framing	Violence emerges dynamically through interpersonal interaction shaped by environment and system pressures	Drew et al.; ILO/WHO frameworks
Regulatory framing	Workplace violence treated as a preventable psychosocial hazard requiring systematic control	Safe Work Australia; NHS VPR Standard

Table 1. Definitions and typology of occupational violence in paramedicine and emergency care.

Contemporary paramedicine scholarship further highlights identity targeted aggression, such as sexist, racist, or homophobic abuse, not only because of its disproportionate emotional impact but also because it remains markedly under documented in routine reporting systems. This broader conceptualization aligns with international EMS reviews that define violence as encompassing both physical and psychosocial harm (Murray et al., 2020), as well as with qualitative analyses depicting aggression as intentional acts directed at paramedics during out of hospital care (Drew et al., 2024). Although this framing now appears well established, the issue has been recognized in the profession for decades. Industry commentary on violent patient encounters emerged within a decade of EMS gaining formal recognition, with Lewis and colleagues (1978) documenting aggression toward responders and articulating the early insight that "aggression begets aggression" (Lewis, 1978). By the late 1990s, EMS researchers were already quantifying the problem, with prospective field studies recording violent episodes in approximately 5% of calls (Mock et al., 1998) and subsequent surveillance work demonstrating high rates of verbal aggression alongside persistent limitations in routine documentation systems (Taylor et al., 2023).

Australian work health and safety guidance similarly conceptualizes workplace violence and aggression as behaviors capable of causing physical or psychological harm. This imposes duties on employers to identify hazards, implement controls, and continually reassess risk (Safe Work Australia, 2024). National surveillance and EMS specific studies demonstrate pervasive and often under reported exposure to occupational violence, reinforcing the need for structured, system level prevention rather than individual coping strategies (McGuire et al., 2025; Murray et al., 2020; Paulin et al., 2024; Taylor et al., 2023).

Global frameworks, particularly those developed through the ILO/ICN/WHO/PSI Joint Program, emphasize that workplace violence in the health sector arises from multidimensional and interacting causes. These seminal works depict violence as an interactional process in which escalation often emerges from interpersonal dynamics shaped by communication patterns, relational cues, and environmental pressures, rather than being simply the result of static or intrinsic "patient factors." In line with this understanding, the frameworks advocate for coordinated policy development, structured and systematic risk assessment, evidence based workplace interventions, and continuous monitoring and evaluation, cautioning against reactive or ad hoc approaches (International Labour Office et al., 2002).

A key implication of this multidimensional framing is that studies employing narrow definitions, such as counting only physical assaults, inevitably underestimate the true burden of OV and distort cross study comparisons. Conversely, using broad definitions without careful attention to denominators can inflate headline prevalence figures in ways that shed limited light on operational risk or actionable system improvements.

Denominators and Their Consequences

A persistent methodological challenge across the OV literature is the substantial variability introduced by denominator selection and recall windows, both of which strongly influence reported prevalence. Career lifetime denominators, for example, consistently yield the highest estimates. Systematic reviews indicate that between 57% and 93% of EMS personnel experience some form of violence at least once during their careers

(Murray et al., 2020); however, these cumulative figures offer limited operational value because they do not capture frequency, recency, or exposure adjusted risk. Twelve month recall windows provide a more practical basis for monitoring trends, yet they still suffer from under reporting, partly due to the cultural normalization of violence within paramedicine (Mausz, Braaksma, et al., 2024).

Near miss reporting systems, such as the National Firefighter Near Miss Reporting System, contribute important contextual detail by capturing precursors and situational hazards, including assault risks, environmental threats, and PPE failures. However, in the absence of standardized denominators, these systems primarily support hypothesis generation and learning rather than providing accurate incidence benchmarks (International Association of Fire Chiefs (IAFC), 2005; Murff et al., 2005).

Recent advances in EMS data architecture have begun addressing these limitations by embedding reporting at the point of care. Point of event reporting integrated into electronic patient care records (ePCRs) has substantially increased the capture of violent encounters and enabled the identification of high risk call types using dispatch level markers (Mausz & Donnelly, 2023). Mission based denominators such as incidents per 1,000 missions, provide more exposure adjusted measures by linking violence to discrete operational events. For example, a large Finnish cohort study found that violent behavior occurred in 0.7% of all EMS missions (297 of 40,263), with predictors identifiable through ePCR text mining approaches (Paulin et al., 2024). These developments demonstrate how denominator standardization can support more meaningful comparisons and inform targeted operational responses.

Despite increasing conceptual clarity in recent years, definitional inconsistency remains a major barrier to comparability across the OV literature. Studies vary widely in what they classify as violence, ranging from verbal abuse and threats to physical assault, and in how they distinguish aggression, near miss events and related behavioral precursors. These variations are further compounded by differences in how incidents are coded across reporting systems (Mausz, Braaksma, et al., 2024; Mausz, D'Eath, et al., 2024). Qualitative work in Australian paramedicine demonstrates that aggressive behavior often emerges through dynamic and relational interactions at scenes, challenging static or overly reductive typologies and underscoring the need for EMS specific taxonomies that better reflect the realities of out of hospital care (Drew et al., 2024).

Cross sector evidence similarly shows that effective mitigation strategies are multilayered and context dependent, reinforcing the importance of shared operational definitions to support robust evaluation and comparative learning (Hu et al., 2022) (Table 2).

International guidance provides useful definitional scaffolding, outlining core elements such as rights and responsibilities, recognition and assessment, intervention strategies, and monitoring and evaluation. These frameworks can be adapted to EMS contexts to strengthen consistency, enhance interoperability across systems, and enable meaningful, system wide learning (International Labour Office et al., 2002).

Denominator Type	Typical Recall Window	Reported Prevalence Range	Strengths	Key Limitations	Representative Sources
Career lifetime	Ever experienced	57–93%	Highlights cumulative burden	No temporal or exposure specificity	Murray et al.; Shabanikiya et al.
12 month recall	Past year	~50–75%	Allows annual trend tracking	Recall bias; under reporting of "minor" events	Bigham et al.; Sahebi et al.
Per mission (ePCR)	Point of event	~0.5–1% of missions	Exposure adjusted; operationally actionable	Captures only documented events	Paulin et al.
Incident reporting systems	Variable	Highly variable	Supports local learning	Strongly shaped by reporting culture	Mausz et al.
Near miss databases	Event based	Not prevalence based	Captures precursors and hazards	No standard denominator	IAFC Near Miss

Table 2. Denominators, recall windows, and their impact on reported prevalence.

Prevalence Heterogeneity and What it Means for Benchmarking

Survey and mixed methods research shows that paramedics experience high levels of OV, although reported prevalence varies with study design, definitional scope and recall window. (Table 3).

Study / Review	Setting	Violence Types Included	Prevalence Estimates	Noted Heterogeneity Drivers
Murray et al. (2020)	EMS	Verbal–sexual	57-93% lifetime	Definitions, recall windows, sampling
Shabanikiya et al. (2021)	Paramedics	Overall; verbal; physical; sexual	66%; 58%; 25%; 16%	Tools, regions, scope
Sahebi et al. (2022)	Hospital + prehospital	Overall; verbal; physical; sexual	58.7%; 66.8%; 20.8%; 10.5%	Context dilution; population mix
International position statements	EMS	Threats & violence	55-83%	Non standardized reporting
Canadian survey (Bigham)	Paramedics	Broad	75% (12 month)	Self report; recall bias

Table 3. Prevalence of OV in paramedicine and emergency care: summary of major syntheses.

In a mixed methods survey of 1,676 Canadian paramedics, 75% reported at least one form of violence in the preceding 12 months, with verbal assault (67%) most common, followed by intimidation (41%), physical assault (26%), sexual harassment (14%), and sexual assault (3%) (Bigham et al., 2014). Point of event reporting programs in Canada reinforce this pattern that verbal abuse is the modal exposure and demonstrate substantial under reporting in routine systems (Mausz et al., 2023). More mixed methods programs further confirm that violence is widespread, chronic, and systematically under reported, with organizational cultures that normalize aggression as "part of the job" compounding incomplete documentation (Mausz & Donnelly, 2023; Mausz et al., 2022) (Table 3).

Global syntheses converge on the same message while highlighting major methodological heterogeneity. Murray et al. (2020) reported career lifetime exposure estimates of 57–93%, with verbal abuse typically most prevalent, followed by physical violence and sexual harassment, noting substantial variability arising from differences in definitional thresholds, sampling frames, and recall periods (Murray et al., 2020). These patterns align with international position statements indicating that 55-83% of EMS personnel report threats or violence while on duty (Paramedic Chiefs of Canada, 2019). Meta analytic work strengthens this picture. A paramedic specific systematic review and meta analysis

by Shabanikiya et al. (2021) reported pooled prevalence estimates of 66% for overall violence, 58% for verbal violence, 25% for physical violence, and 16% for sexual harassment, with between study variability attributable to divergent definitions, measurement tools, and regional contexts; this heterogeneity is echoed in broader global analyses (Shabanikiya et al., 2021). An umbrella review by Sahebi et al. (2022), spanning hospital and prehospital settings and including EMTs, found pooled prevalence estimates of 58.7% for any workplace violence, 66.8% for verbal violence, 20.8% for physical violence, and 10.5% for sexual harassment, again underscoring wide methodological and contextual variation (Sahebi et al., 2022).

Collectively, these syntheses show that while OV is consistently prevalent across paramedicine and wider emergency care, inconsistencies in definitions, sampling frames, and operational contexts limit the interpretability of headline rates and point to the need for region specific, methodologically aligned benchmarking (Sahebi et al., 2022; Shabanikiya et al., 2021).

Australasian evidence mirrors these global findings. International systematic reviews indicate that violence in paramedicine is persistent, recurrent, and embedded in routine practice rather than rare or episodic, with EMS personnel experiencing repeated exposures over time (Maguire, 2018). Australian injury surveillance shows that assault related harms constitute a consistent component of paramedic occupational risk across multiple years (Maguire et al., 2014). Qualitative work from the region highlights entrenched, system level features, including cultural normalization and barriers to prevention, while contemporary point of event studies confirm that violence occurs across call types, at scenes, in transit, and during ED handover, with predictors spanning patient factors, environmental context, and system level contributors such as delays and resourcing constraints (Drew et al., 2024; Paulin et al., 2024; Sawyer et al., 2020).

For benchmarking within ambulance services, this heterogeneity demands caution, as single "headline prevalence" figures risk oversimplifying a complex, multifactorial phenomenon. A more informative approach is to use a bundle of indicators that capture exposure by type (e.g., verbal aggression, intimidation, physical violence, sexual harassment), severity (e.g., injuries requiring treatment, psychological harm, lost workdays), contextual variables (e.g., scene environments, mental health related calls, intoxication related presentations, ED handover delays), and reporting completeness, namely, the proportion of incidents formally reported versus those identified through narrative or point of event tools. Research on point of event reporting shows that reporting behavior is shaped by organizational culture, perceived consequences, and system accessibility, making reporting completeness a critical benchmarking dimension (Mausz, Braaksma, et al., 2024). In parallel, system architecture analyses demonstrate that definitions, workflow integration, and data capture maturity substantially influence the visibility of violent events, factors that must be accounted for when comparing services (Mausz & Donnelly, 2023).

The Measurement Gap: Under Documentation, Under Reporting, and the Evaluation Paradox

A growing body of international research shows that routine clinical documentation substantially underestimates the true burden of OV for paramedics, creating a significant measurement gap between experienced and recorded events. Record based analyses

frequently capture only a small fraction of violent episodes, particularly verbal and identity targeted aggression, while dedicated point of event systems reveal a far richer and more nuanced picture of exposure and harm (Table 4).

Dimension	Survey / Qualitative Evidence	Routine Documentation	Point of Event Reporting
Verbal abuse	Common	Rarely captured	Frequently captured
Identity targeted violence	Common	Largely absent	Explicitly recorded
Near miss events	Widely reported	Absent	Routinely recorded
Contextual detail	Rich	Minimal	High
Psychological harm	Reported	Rare	More visible
Reporting drivers	Culture, safety, meaning	Administrative burden	Workflow integration

Table 4. The measurement gap: experienced vs documented occupational violence.

This discrepancy is illustrated by recent international findings. In Finland, violence was documented in only 0.7% of 40,263 EMS missions, predominantly verbal aggression, despite identifiable predictors such as male patient sex, alcohol involvement, urban settings, and weekend nights, factors that should make many episodes detectable within operational data. Yet the overall documentation rate remained low In England where the 2023 NHS Staff Survey found that approximately 14% of staff experienced physical violence and around 25% experienced harassment, bullying, or abuse from patients or the public in the previous year. NHS England highlights the importance of considering Staff Survey data alongside organizational incident reporting to understand the full extent of violence and abuse experienced by staff (NHS England, 2024). Complementary evidence from NHS Resolution's 2024 thematic review highlights significant reporting and data integration gaps at provider level, calling for strengthened governance and improved completeness of incident capture (NHS Resolution, 2024).

Studies beyond Europe underline the scale of global under documentation. A mixed methods systematic review of 58 studies across 30 countries found that verbal, discriminatory, and identity targeted abuse is rarely reported through formal channels due to organizational, cultural, and interpersonal barriers (Xu et al., 2025). In Canada, point of event analysis using EVIR data showed that one in four violent reports included sexist, racist, or homophobic abuse, categories largely invisible in routine datasets prior to reporting reform (Mausz, Braaksma, et al., 2024; Mausz, D'Eath, et al., 2024). These findings demonstrate that the documentation gap is both quantitative (missed incidents) and qualitative (missed content, especially identity targeted aggression).

Several interacting factors explain why survey based prevalence estimates consistently exceed rates derived from clinical records. Variability in definitions, particularly whether verbal harassment or discriminatory abuse "counts," suppresses documentation (Spencer et al., 2023; Xu et al., 2025). Operational pressures in urgent, time critical prehospital environments limit opportunities to record threats or sudden behavioral escalation in detail (Paulin et al., 2024). Cultural normalization of OV and perceptions that reporting is futile further deter documentation, patterns that are repeatedly identified in reviews and guidance (Mausz & Donnelly, 2023; National Institute for Occupational Safety and Health, 2024b). These barriers can disproportionately affect minority staff, who experi-

ence elevated risks of harassment and discrimination and may have less confidence that reporting will prompt an effective organizational response (NHS England, 2025).

The consequences of this systematic under documentation are substantial, and multiple jurisdictions describe an evaluation paradox. When organizations improve reporting systems, such as embedding point of event mechanisms in ePCRs, simplifying prompts or strengthening psychological safety, documented incidents often rise initially (Mausz & Donnelly, 2023). In Peel Region (Ontario), a two year implementation generated 941 structured violence reports, interpreted as evidence of improved capture and increased confidence to report rather than a deterioration in safety (Mausz et al., 2023).

Similarly, England's refreshed Violence Prevention and Reduction (VPR) Standard requires organizations to demonstrate data and evaluation capability and to interpret incident trends in light of reporting maturity and safety culture (NHS England, 2024) (Table 5).

Reporting Change	Observed Effect	Interpretation Risk	Correct Interpretation
ePCR embedded reporting	Incident counts rise	"Violence is increasing"	Reporting completeness improved
Simplified reporting	More non physical events	"Trivial incidents logged"	Previously hidden burden
Psychological safety initiatives	Increased reporting	"Staff less resilient"	Increased trust
Improved data linkage	Better pattern detection	"New risk emerging"	Visibility of existing risk

Table 5. The evaluation paradox in violence surveillance.

Accordingly, there is growing international consensus that reporting completeness must be treated as an outcome in its own right. NHS Resolution's 2024 thematic review highlights weaknesses in data capture, learning, and governance related to workplace violence incidents and calls for strengthened organizational oversight and use of violence data to inform prevention efforts (NHS Resolution, 2024).

The UK Government's April 2025 commitment to mandatory national level collection aims to close long standing data gaps that impede targeted prevention. In practice, indicators such as reporting latency, follow up completeness, concordance between narrative clinical documentation and incident logs, and staff perceptions of psychological safety are increasingly recognized as measures of system maturity, with triangulation across data sources recommended in surveillance frameworks such as EMERG (Department of Health and Social Care (DHSC), 2025; National Institute for Occupational Safety and Health, 2024a).

For Australasian ambulance services, these lessons have direct relevance. Evaluating violence prevention must look beyond raw incident counts to incorporate data quality, reporting behavior, and organizational readiness. This means interpreting rising incident numbers as potential markers of healthier reporting culture, triangulated with exposure adjusted indicators and harm outcomes, rather than assuming deteriorating operational risk. Such an approach enables services to recognize genuine reductions in harm while avoiding misinterpretation of improvements in transparency as signs of worsening safety (Mausz & Donnelly, 2023; Paulin et al., 2024).

Risk Contexts and Operational Predictors

Across diverse health systems, most OV encountered by paramedics is initiated by patients, with relatives or bystanders contributing variably across contexts. Multi city surveillance in the United States, using an enhanced reporting system, found that patients were responsible for 73% of assailants and that verbal aggression occurred in 81% of recorded events. Much of this violence emerged from people in acute crisis, with emotional stress reported as the most frequent injury and mental injury severity often exceeding physical harm (Taylor et al., 2023). Qualitative work from Sweden similarly highlights the predominance of patient origin violence while underscoring challenges with police cooperation, the need for clear role allocation, and the potential for relatives to escalate scenes in emotionally charged circumstances (Stjerna Doohan et al., 2024).

International evidence consistently identifies intoxication, mental health crisis, and acute behavioral disturbance (ABD) as major risk contexts. In Finland, alcohol involvement was the strongest predictor of documented violence (OR = 3.464), with urban environments and weekend nights further elevating risk (Paulin et al., 2024). Studies from the Middle East echo these patterns. In Riyadh, emergency department research indicates that workplace violence, predominantly verbal, is widely experienced by healthcare providers, with under reporting linked to cultural normalization and limited confidence in reporting processes (Al-Wathinani et al., 2023). Similarly, a survey of public hospital emergency departments in Dammam reported an annual workplace violence exposure of 47.8%, with under reporting again described as common (Harthi et al., 2020).

The clinical literature describes acute behavioral disturbance (ABD) as a rapidly evolving, physiologically unstable medical emergency, most commonly associated with stimulant or other psychoactive substance use and frequently misinterpreted as primary psychiatric illness. Standard restraint based approaches may exacerbate physiological deterioration and worsen outcomes, highlighting the need for early medical control, minimization of restraint, and structured approaches to de escalation and sedation (Royal College of Emergency Medicine, 2023; Stevenson & Tracy, 2021).

Operational predictors show striking consistency across jurisdictions. Violent incidents tend to cluster during high demand temporal windows, especially weekend nights, and within densely populated urban areas. In Finland, urban environments increased risk by approximately 70% and weekend nights by 35% (Paulin et al., 2024). Contemporary US surveillance shows similar concentration in metropolitan systems, where behavioral emergencies intersect with social vulnerability, reflecting structural determinants of risk (Taylor et al., 2023) (Table 6).

Risk Context	Evidence Consistency	Key Findings	Operational Implications
Intoxication	High	Strongest predictor	Early staging; backup
Mental health crisis / ABD	High	Rapid escalation risk	Structured de escalation
Urban environments	Moderate–high	Higher density risk	Resource allocation
Weekend nights	Moderate	Temporal clustering	Staffing models
ED handover delays	High (Australasia)	Prolonged exposure	System coordination
Police co response	Variable	Does not eliminate risk	Ongoing vigilance

Table 6. Recurrent risk contexts and operational predictors of violence.

Qualitative and operational studies repeatedly emphasize unpredictability, including during co response. Finnish reports note that violence "sometimes occurred suddenly although the police were present," illustrating that police attendance does not eliminate risk (Paulin et al., 2024). Canadian qualitative work describes some mental health related calls as deceptively calm until abrupt escalation, with distress, fear, or perceived threat around procedures triggering aggression (Ford Jones, 2023). Australian research likewise shows that aggression frequently emerges from dynamic interpersonal interactions shaped by communication, environmental pressures, and relational cues rather than clinical pathology alone (Drew et al., 2024).

These patterns highlight the importance of anticipatory risk assessment. The Aggressive Behavior Risk Assessment Tool (ABRAT)-EMS, adapted from a validated ED tool, demonstrates strong predictive performance with an Area Under the Curve (AUC) of 0.89 in prehospital care. It uses concise indicators such as agitation, confusion, and threatening behavior to identify elevated risk early during patient contact (Kim et al., 2025). ED implementations of the related ABRAT ED have demonstrated violence reduction when paired with targeted signage and workflow adjustments (Kim et al., 2024). These tools are particularly relevant for mental health related calls, which are estimated to comprise approximately 5-15% of 911 activations in some jurisdictions and are commonly addressed through integrated police-mental health co response models (Eloi et al., 2025).

International evidence consistently supports layered operational controls rather than reliance on any single intervention. Swedish clinicians emphasize flexible communication, continuous safety appraisal, and clear role delineation, even when police are present (Stjerna Doohan et al., 2024). Australian and Canadian studies similarly advocate for bundled approaches that combine staging and withdrawal criteria, calm de escalation strategies, supervisory support, tailored staffing, and co response frameworks during predictable high risk periods (Drew et al., 2024; Ford Jones, 2023).

Consequences for Clinicians, Patient Interactions, and Systems

The OV in paramedicine extends well beyond the immediate harms of physical assault. Qualitative evidence from a large multistate U.S. EMS agency shows that repeated exposure to violence gradually reshapes clinicians' approach to patient care, heightening vigilance, eroding trust, and promoting emotional distancing that diminishes compassion and affects subsequent encounters. These themes, personal impact, altered patient interactions, and concerns about career sustainability, are central to the lived experience of frontline paramedics (McGuire et al., 2025). Australian qualitative work similarly demonstrates that aggression is inherently relational and interactional. Paramedics describe withdrawing from therapeutic engagement, modifying communication and operating under persistent anticipatory threat, patterns that plausibly degrade patient experience and the effectiveness of care long after a precipitating incident (Drew et al., 2024).

Psychological sequelae are substantial. A recent systematic review and meta analysis found that post traumatic stress disorder (PTSD) affects a markedly higher proportion of paramedics, with 12 month prevalence estimates commonly approaching one in five, compared with approximately 3% in non exposed working age populations (Hoell et al., 2023). Across the broader first responder literature, post traumatic stress disorder (PTSD)

symptom prevalence is estimated to range from approximately 7% to 37%, reflecting cumulative exposure to threats, assaults, and traumatic events, and aligning with prevalence estimates reported in paramedic specific meta analyses (Lewis-Schroeder et al., 2018; Yu, 2024).

A systematic review commissioned by the U.S. Agency for Healthcare Research and Quality (AHRQ) documents markedly elevated rates of suicidal ideation among EMS clinicians, estimated at approximately 33% in some samples, alongside mild to severe burnout and occupational stress, and identifies low strength evidence that mindfulness based interventions may reduce burnout for up to six months following implementation (Agency for Healthcare Research and Quality, 2024; Agency for Healthcare Research and Quality, 2025). Organizational context amplifies these psychological effects, as perceived futility of reporting, limited managerial support and the normalization of abuse all contribute to emotional burden. Qualitative data repeatedly describe a culture in which workplace violence is viewed as an accepted part of the job with enduring consequences for wellbeing and professional identity (McGuire et al., 2025). Consistent with this, UK ambulance research documents high levels of burnout among frontline staff, with substantial proportions reporting moderate to severe emotional exhaustion and depersonalization, raising concerns about sustained impacts on wellbeing, empathy, and patient centered care (Beldon & Garside, 2022).

Violence related consequences reverberate through workforce capacity and health system sustainability. Surveillance data from the National Institute for Occupational Safety and Health (NIOSH) estimate that approximately 16,900 EMS clinician injuries were treated in U.S. emergency departments in 2020, with events including violence, overexertion, harmful exposures, and transport incidents (National Institute for Occupational Safety and Health (NIOSH), 2024).

The cumulative impact of injury, violence, and unsafe working conditions extends beyond individual harm to undermine workforce sustainability. Workforce turnover remains high, with American Ambulance Association (AAA) studies reporting annual turnover rates of 20-36% among EMTs and paramedics, equating to near-complete workforce turnover every three to four years. Such instability poses a significant risk to workforce continuity and the maintenance of high-quality care (American Ambulance Association, 2022, 2024). Burnout further undermines sustainability as it was demonstrated by a national analysis, reported in the Journal of the American College of Emergency Physicians. The results of this analysis showed a high burnout prevalence and significantly increased odds of 10 sick days, as well as two to three fold higher intention to leave the profession among burned out EMS clinicians (Powell et al., 2025).

Additional synthesis work for the AHRQ EMS/911 systematic review confirms high prevalence of depression, anxiety, PTSD, stress, and burnout among EMS personnel. The review protocol highlights a large 2019 survey in which 60% of EMS respondents endorsed feeling burned out and 36% reported not wanting to continue in EMS, signaling significant risks to professional longevity (Agency for Healthcare Research and Quality (AHRQ), 2024). The completed AHRQ executive summary (2025) reinforces these findings, identifying substantial mental health morbidity, including suicidal ideation in some EMS samples, and noting that while interventions such as mindfulness may offer short term reductions in burnout, longer term, system level reforms remain necessary (Agency

for Healthcare Research and Quality, 2025). When viewed alongside qualitative evidence on culture, relational consequences and identity related impacts (McGuire et al., 2025), and policy syntheses on first responder PTSD prevalence and barriers to accessing support (Yu, 2024), the data collectively point to a sustained risk of reduced workforce participation and declining intention to remain in EMS unless organizational reforms directly address OV, its reporting environment, and its cultural entrenchment (Table 7).

Domain	Documented Consequences	Supporting Evidence
Psychological health	PTSD, anxiety, burnout, suicidal ideation	Hoell et al. (2023); AHRQ (2024,2025)
Clinical behavior	Emotional distancing, reduced trust	Drew et al. (2024); McGuire et al. (2025)
Workforce outcomes	Sick leave, turnover intention	Powell et al. (2025); AAA (2024, 2025)
System sustainability	Staffing instability, care continuity risk	NIOSH (2024); AHRQ (2025)

Table 7. Consequences of occupational violence for clinicians and systems.

Australasian Administrative Data from Ambulance Services (2021-2023)

In Australasia, we integrated the 2021-2023 administrative data available from Australian and New Zealand ambulance services to illustrate exposure-adjusted benchmarking challenges and definitional variance.

Across the combined dataset, a total of 2,368 incidents of OV were recorded for the 2021-2022 and 2022-2023 financial years. This includes 1,159 physical incidents, 998 non-physical incidents, and 211 unintentional events. This distribution reflects the broader pattern observed internationally, where non physical aggression, such as verbal abuse, threats, and intimidation, constitutes a substantial proportion of total exposure, while physical violence remains a significant and persistent operational risk (Table 8).

Incident Category	Number of Incidents
Physical violence	1,159
Non physical violence	998
Unintentional incidents	211
Total	2,368

Table 8. Australasian administrative OV data (2021–2023): aggregate illustration.

The relative proportion of unintentional incidents is considerably smaller but still meaningful. This finding underscores the need to recognize not only deliberate acts but also behavioral and environmental factors that can lead to accidental harm. When interpreted collectively, these totals highlight both the magnitude of OV affecting paramedics in the Australasian context and the methodological challenges inherent in aggregated reporting, as variations in definitions, category, scope, and reporting maturity across services influence the overall composition of the data.

DISCUSSION

Three syntheses of international and Australasian evidence on OV reveals three methodological principles that are essential for producing accurate, comparable, and operationally meaningful violence data in paramedicine. These principles include denominator discipline, integrated reporting architecture, and contextual exposure indicators, which address longstanding limitations in how OV is measured, interpreted, and used to inform prevention.

Denominator Discipline: Why Exposure Adjusted Metrics Are Essential

The reported prevalence of occupational violence among paramedics varies considerably across studies. This variation is largely attributable to inconsistencies in exposure definitions, reporting systems, and denominator selection across jurisdictions. A key finding across the literature is the extent to which denominator choice influences reported prevalence estimates. Career lifetime recall surveys routinely report that more than half (often more than two thirds) of EMS clinicians experience violence over the course of their careers, with some meta analyses placing exposure between 57% and 93% (Murray et al., 2020; Shabanikiya et al., 2021). These figures are valuable in highlighting cumulative occupational burden but provide little insight into when, where, or under what operational conditions violence occurs. Because career lifetime measures aggregate every violent encounter across many years, they cannot inform risk stratified prevention or real time operational planning.

Twelve month recall denominators offer somewhat more practical information. Yet even these are influenced by recall bias, inconsistent definitions of "violence," and pervasive cultural normalization among paramedics. This tendency is well documented in both qualitative studies and mixed methods surveys, where many clinicians report only "serious" episodes, omitting verbal, discriminatory, or escalating behaviors that nonetheless shape risk.

For operational decision making, the evidence clearly favors mission based denominators, such as incidents per 1,000 missions or per 10,000 patient contacts. Operational datasets should therefore link each OV event to a defined mission denominator, incorporating dispatch category, time stamp, location type, and crew configuration to enable stratified risk modeling. These allow exposure to be linked to discrete operational units including call types, times, locations, and environmental conditions. Research using integrated ePCR and reporting systems shows the power of this approach. For example, a Finnish cohort analysis of more than 40,000 missions identified violence in 0.7% of all missions, which appears low in isolation but becomes highly meaningful when paired with contextual predictors such as alcohol involvement, urban location, and weekend nights, which substantially increased risk (Paulin et al., 2024). This granularity would be completely lost in a recall based design.

Mission based denominators also enable quasi experimental evaluation methods, including interrupted time series and stepped wedge rollouts, because the underlying exposure unit is stable, comparable, and unaffected by subjective recall. This methodological discipline aligns with emerging EMS research that seeks to move beyond descriptive prevalence toward evaluated prevention, where risk is quantified, interventions targeted, and outcomes measured against exposure adjusted baselines. In this way, denominator discipline becomes the foundation for both surveillance and system level improvement.

Reporting Architecture: Embedding Capture in Everyday Workflow

A second methodological principle is the need for a reporting architecture that is deeply integrated into paramedic workflow, particularly through electronic patient care records. The literature consistently shows that routine incident systems dramatically under record OV. Verbal abuse, intimidation, identity targeted harassment, and near miss events are especially likely to be omitted, both because clinicians often perceive them as inevi-

table features of the job and because traditional reporting processes are time consuming, poorly aligned with workflow, or perceived as unlikely to lead to meaningful action.

The under reporting problem is not limited to low severity events. Studies comparing administrative datasets with point of event reporting mechanisms reveal stark discrepancies. In Peel Region (Ontario), the introduction of an ePCR embedded reporting tool produced 941 violence reports in 24 months, far exceeding historical incident counts and uncovering patterns, such as the prevalence of sexist, racist, and homophobic abuse, that had previously been largely invisible in routine systems. These insights fundamentally altered the service's understanding of both the scale and nature of OV risk (Mausz, Braaksma, et al., 2024; Mausz & Donnelly, 2023).

However, embedding reporting into workflow introduces a critical interpretative complication. When reporting improves, incident counts may increase even if underlying risk is stable or declining, reflecting the well-recognized evaluation paradox. Without complementary metrics, such increases may be misinterpreted as worsening violence, leading to inaccurate operational conclusions. Accordingly, mature surveillance systems must integrate indicators of reporting quality, including completeness, latency, and concordance across narrative documentation, incident reporting systems, and ePCR data. These measures enable differentiation between true changes in occupational risk and artifacts of improved reporting behavior or system design.

This principle aligns with violence prevention governance standards internationally. For example, the NHS Violence Prevention and Reduction Standard explicitly require organizations to demonstrate data maturity, reporting accessibility, and regular review cycles to ensure consistent interpretation of incident trends (NHS England, 2024). Similar expectations are embedded in Australasian psychosocial hazard regulations, which emphasize employer responsibility for capturing and analyzing psychosocial harm and environmental risk factors (Safe Work Australia, 2024).

To address heterogeneity across domains of occupational violence, it is important to distinguish not only between types of violence but also their underlying operational drivers. Physical violence is most consistently associated with acute behavioral disturbance, substance intoxication, and high-acuity clinical presentations requiring rapid scene management in uncontrolled environments, reflecting reduced behavioral regulation and limited scene predictability during emergency response. In contrast, verbal abuse and threats are more commonly linked to prolonged waiting times, perceived delays in response, and heightened emotional distress among patients and bystanders, reflecting system-interface stress and unmet service expectations. Sexual harassment and identity-based aggression appear more strongly associated with contextual and environmental vulnerability, including low visibility settings, single-crew deployments, and reduced situational control during transport or offload delays. These distinctions suggest that occupational violence in paramedicine is not a uniform phenomenon, but rather a spectrum of behavior shaped by different clinical, environmental, and system-level stressors.

Contextual Exposure Indicators: Illuminating the Conditions That Generate Risk

While denominator discipline and robust reporting systems clarify how often violence occurs, they cannot fully explain why or under what conditions. The third methodolog-

ical principle addresses this gap by emphasizing the importance of contextual exposure indicators, as measures that quantify the operational conditions known to amplify risk.

The literature makes clear that OV clusters in predictable contexts such as intoxication, acute behavioral disturbance, mental health crises, and emotionally charged family environments, and at predictable operational interfaces, particularly the ambulance-ED handover zone. These contexts rarely arise in isolation; they interact with system pressures such as crowding, delays, and inadequate information flow.

One critical contextual indicator is time to backup. When police, clinical supervisors, or additional crews are delayed, paramedics spend longer in uncontrolled environments where risk may escalate suddenly. Several qualitative and observational studies describe clinicians feeling "trapped," "outnumbered," or "unsupported" during prolonged waits, especially when managing intoxicated or agitated individuals. These prolonged exposures heighten emotional intensity, increase bystander agitation, and limit opportunities for tactical withdrawal.

A second contextual indicator is staging duration. Staging is a protective measure intended to reduce exposure before scene safety is confirmed. Yet staging duration can become counterproductive when delays result from systemic issues, such as insufficient police availability, ambiguous dispatch information, or conflicting caller descriptions. Prolonged staging may heighten risk by delaying patient assessment, prolonging bystander distress, or undermining trust when a visibly distressed or intoxicated patient perceives the ambulance as "waiting outside." Tracking staging duration helps services distinguish between clinically appropriate safety behavior and operational bottlenecks that inadvertently escalate scene volatility.

A third indicator of significant importance is ED handover exposure time. The ambulance-ED interface is consistently identified as one of the most violence prone environments. Crowding, long waits, distressed relatives, limited security staffing, and the emotional intensity of emergency settings converge to create conditions ripe for aggression. Australasian data underscore the scale of the problem. South Australia recorded 45,399 hours of ramping in 2023-2024, and only 47% of patients were transferred within recommended timelines (Australian Medical Association, 2025). Each additional minute a paramedic spends in congested corridors or triage areas increases exposure to frustrated patients and families, particularly during periods of access block and resource strain.

Together, these contextual indicators illuminate why occupational violence occurs in particular patterns. Mechanistically, this reflects increased cognitive load, delayed backup availability, and reduced situational control in dynamic prehospital environments. These conditions allow services to detect operational drift, such as gradually lengthening handover delays or increasing response times for police co-attendance, long before incident numbers alone would signal concern. They also help attribute changes in occupational violence rates to underlying system pressures rather than superficial interpretations of "increasing violence." This distinction is vital for ensuring that prevention strategies address root causes not symptoms.

Bringing the Principles Together

When combined, these methodological principles form the scaffolding of a mature OV surveillance and prevention system. Denominator discipline ensures that prevalence estimates reflect exposure. Integrated reporting architecture ensures that data are visible, complete, and timely.

Principle	Purpose	Key Indicators
Denominator discipline	Exposure adjusted measurement	Incidents per 1,000 missions
Integrated reporting	Complete, timely capture	Reporting latency; completeness
Contextual exposure indicators	Explain why risk occurs	Time to backup; staging duration; ED handover time
Triangulation	Valid interpretation	Surveys + ePCR + incident systems

Table 9. Methodological principles for mature ov surveillance and prevention.

Contextual exposure indicators ensure that the operational conditions that generate risk are measured and monitored. Together, they align with modern regulatory frameworks for psychosocial hazard management and with emerging models of system level violence prevention.

Translating these findings into practice requires three parallel system-level actions. The first is the standardization of violence taxonomies across EMS jurisdictions. The second is the embedding of exposure-adjusted reporting within electronic patient care records. The third is the development of national benchmarking dashboards incorporating both incident and reporting-completeness indicators. Without these steps, comparisons between services will continue to reflect measurement artifacts rather than true differences in risk.

LIMITATIONS

The evidence base is heterogeneous. Definitions, recall windows, sampling frames, and documentation practices vary widely. Administrative data under capture events, while survey data are vulnerable to selection and recall bias. We therefore emphasized triangulation, denominator discipline, and reporting completeness rather than pooled prevalence estimates.

CONCLUSIONS

OV in paramedicine is common, patterned, and under documented. Regions aiming to benchmark and reduce risk should: (1) standardize definitions across systems; (2) adopt exposure adjusted, mission based denominators; (3) embed point of event reporting into workflow and track reporting completeness/latency/concordance; and (4) use paired leading/lagging indicators that include contextual exposure (time to backup, handover delay). These principles provide the measurement foundation for evaluating systems level prevention, detailed in the companion paper.

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REVIEWS

RETHINKING PREHOSPITAL FLUID RESUSCITATION FOR MASSIVE PULMONARY EMBOLISM: A NARRATIVE LITERATURE REVIEW

Elena Kalkidis*[1]; Joshua Martin[1]; Jean-Paul Veronese[1]

Author Affiliations: 1. School of Medicine and Dentistry, Bachelor of Paramedicine Program, Griffith University, Gold Coast Campus, QLD, Australia.

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**Corresponding Author:* etrinity10@outlook.com

ABSTRACT

Background: Massive pulmonary embolism (PE) is characterized by sustained hypotension and right ventricular (RV) dysfunction, resulting in high morbidity and mortality. Although these patients present hemodynamically unstable, hypotension arises from obstructive shock rather than hypovolemia. Despite this, fluid resuscitation (FR) remains common in prehospital care, and its role in massive PE remains controversial.

Objective: This review aimed to evaluate the efficacy of FR in adult patients with massive PE, with consideration of its implications for prehospital care.

Methods: A narrative literature review was conducted in April 2026 using Ovid MEDLINE and EMBASE (1950–April 2026). Due to the paucity of prehospital data, both human and animal studies examining any form of fluid therapy in massive PE were included. Non–peer-reviewed literature, unrelated conditions, and systematic reviews were excluded. Nine peer-reviewed studies met inclusion criteria.

Results: Fluid administration in massive PE was associated with worsened RV dysfunction, reduced cardiac output (CO), and increased hemodynamic instability. In contrast, alternative interventions, including positive inotropes and diuretic therapy (DT), were associated with improved RV function, stroke volume (SV), and hemodynamic stability.

Conclusion: The available evidence, although derived largely from animal, retrospective, and hospital-based studies, suggests routine FR in hypotensive patients with massive PE may exacerbate RV failure and compromise CO. Prehospital management should therefore consider strategies that support RV function and hemodynamic stability. These findings support reconsideration of FR as a primary intervention in massive PE and highlight the need for evidence-informed prehospital guidelines.

INTRODUCTION

Pulmonary embolism (PE) is a potentially life-threatening condition caused by obstruction of the pulmonary arteries, with an overall mortality of approximately 14.7% even among patients receiving treatment (Fernandes et al., 2019; Konstantinides et al., 2019). Clinical presentation varies according to clot burden and location, ranging from mild dyspnea to profound respiratory and hemodynamic compromise (Mata et al., 2020). Massive PE

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(MPE), defined by sustained hypotension with a systolic blood pressure < 90 mmHg (Banerjee & Mora, 2020; Vyas et al., 2024), carries particularly high risk, with thirty-day mortality reported as high as 57.1%. Sub-massive PE is associated with mortality of approximately 6.7%, and low-risk PE around 3.5% (Gupta et al., 2020). In severe cases, MPE may precipitate cardiac arrest within one to two hours of symptom onset (Mata et al., 2020).

In MPE, hypotension arises from obstructive shock and right ventricular (RV) failure rather than true intravascular volume loss (McGuire et al., 2024). Obstruction of pulmonary blood flow reduces left ventricular preload and cardiac output (CO), producing hypotension despite normal or elevated circulating volume. Although fluid resuscitation (FR) is a mainstay of hypotension management in other shock states, its physiological rationale in MPE is uncertain. Evidence suggests FR may worsen RV dilatation, increase myocardial oxygen demand, and further compromise hemodynamics, with alternative hemodynamic strategies proving more beneficial (Belenkie et al., 1989; Mercat et al., 1999; Mortensen et al., 2020).

Despite evidence questioning the physiological benefit of FR in MPE, many ambulance services both locally (AV, 2025; QAS, 2020) and globally (BCEHS, 2026; NHS, 2025) continue to list FR as a treatment consideration for hypotensive PE in the prehospital setting. This persists in the face of growing literature suggesting FR may exacerbate RV failure and worsen outcomes, while strategies such as vasopressor support or diuretic therapy (DT) with volume removal may better preserve CO and hemodynamic stability (Ferrari et al., 2022; Ternacle et al., 2013). As paramedics are often the first clinicians to manage these patients, early resuscitation decisions may substantially influence hemodynamic trajectory and survival. This review aims to examine and synthesize the current literature on FR in adult patients with MPE, addressing the uncertainty surrounding its hemodynamic effects and informing prehospital clinical management. It evaluates whether FR confers benefit or harm in this high-risk cohort and explores the role of alternative strategies, including DT and vasopressor support, in informing safer and more physiologically aligned prehospital care for patients with MPE.

METHODS

Review Approach

This study utilized a narrative literature review to synthesize existing evidence on FR in PE, with a particular focus on MPE. Narrative reviews aim to consolidate and interpret the current body of knowledge without necessarily undertaking exhaustive searching or formal quality appraisal (Grant & Booth, 2009). They are particularly suited to topics where evidence is limited, heterogeneous, or emerging, and where conceptual understanding is required (Snyder, 2019).

This approach was selected over more structured methodologies (e.g., systematic or scoping reviews) due to the limited and varied nature of the available evidence examining FR in MPE, particularly in the prehospital setting. Additionally, the purpose of this review was to explore physiological and clinical implications of FR rather than formally evaluate the effectiveness of a single intervention.

Search Strategy

A preliminary search of the literature was conducted to refine key terms, followed by electronic searches of Ovid MEDLINE (1950–April 2026) and EMBASE (1966–April 2026). Searches combined Medical Subject Headings (MeSH) and plain-text keywords using Boolean operators (AND, OR), outlined in Table 1. Searches were limited to English-language, peer-reviewed primary research, with grey literature and clinical practice guidelines excluded. Records from both databases were combined and de-duplicated using Ovid's built-in function before title and abstract screening. Reference lists of included studies were also screened for additional relevant literature.

Database	Search Strategy
Ovid MEDLINE	(exp Emergency Medical Services/ OR Emergency Medical Technicians/ OR Emergency Responders/ OR First Aid/ OR exp Ambulances/ OR Air Ambulances/ OR Paramedics/ OR (emergency care OR emergency management OR emergency medical service* OR EMS OR emergency medical team* OR emergency medical technician* OR EMT OR EMTs OR emergency response OR first aid OR first responder* OR prehospital care OR pre-hospital care OR prehospital emergency medical care OR pre-hospital emergency medical care OR acute care OR ambulance service* OR air ambulance* OR paramedic service* OR paramedic*).ti,ab,kf.) AND (exp Fluid Therapy/ OR (fluid* OR fluid therap* OR fluid resuscitat* OR volume expansion OR volume resuscitat* OR intravenous fluid therap* OR hemodynamic support OR haemodynamic support).ti,ab,kf.) AND (exp Pulmonary Embolism/ OR exp Thromboembolism/ OR (pulmonary embol* OR PE OR pulmonary arterial embol* OR thromboembol* OR sub-massive pulmonary embol* OR submassive pulmonary embol* OR massive pulmonary embol*).ti,ab,kf.)
Ovid Embase	(exp emergency health service/ OR exp ambulance/ OR exp Air Ambulances/ OR paramedical personnel/ OR (emergency care OR emergency management OR emergency medical service* OR EMS OR emergency medical team* OR emergency medical technician* OR EMT OR EMTs OR emergency response OR first aid OR first responder* OR prehospital care OR pre-hospital care OR prehospital emergency medical care OR pre-hospital emergency medical care OR acute care OR ambulance service* OR air ambulance* OR paramedic service* OR paramedic*).ti,ab,kw.) AND (exp fluid therapy/ OR (fluid* OR fluid therap* OR fluid resuscitat* OR volume expansion OR volume resuscitat* OR intravenous fluid therap* OR hemodynamic support OR haemodynamic support).ti,ab,kw.) AND (exp pulmonary embolism/ OR exp thromboembolism/ OR (pulmonary embol* OR PE OR pulmonary arterial embol* OR thromboembol* OR sub-massive pulmonary embol* OR submassive pulmonary embol* OR massive pulmonary embol*).ti,ab,kw.)

Table 1. Database search strategies.
Limits: Publication years 1950 to April 2026.
Abbreviations: EMS: emergency medical services; EMT: emergency medical technician; PE: pulmonary embolism.

Inclusion/Exclusion Criteria

Studies were included if they were English-language, peer-reviewed primary research examining the hemodynamic effects of FR in PE in adult populations (18 years), conducted in either prehospital or hospital settings. Where relevant, experimental animal studies were also included to provide mechanistic insight into RV hemodynamics in acute PE, particularly given the limited availability of prehospital human data examining FR in MPE.

Studies were excluded if they focused on unrelated therapies (e.g., thrombolysis, anticoagulation, or embolectomy), non-PE pathologies, or pediatric populations. Abstracts, review articles, clinical practice guidelines, grey literature, non-English-language publications, and non-peer-reviewed publications were also excluded.

Extraction

Elements of the PRISMA framework were used to guide reporting of the search and screening process (Moher et al., 2009). Figure 1 outlines the number of records identified, screened, excluded, and included in the final synthesis.

Two reviewers (EK, JM) independently screened titles and abstracts for relevance, followed by full-text assessment against the inclusion and exclusion criteria. Any differences in study selection were resolved through discussion, with a third reviewer (JV) providing final oversight where required. Following selection, included studies were analyzed to extract key findings relating to hemodynamic outcomes and treatment effects.

As this review was narrative in design, formal critical appraisal tools (e.g., CASP, JBI) were not applied. However, study relevance and methodological quality were considered during the screening process.

RESULTS

The database search identified 542 records across Ovid MEDLINE and EMBASE. Following removal of duplicates and screening of titles and abstracts, 41 full-text articles were assessed for eligibility. Of these, 32 studies were excluded based on predefined criteria, resulting in nine studies included in the final synthesis. The study selection process is illustrated in Figure 1. A summary of included studies is presented in Table 2, and excluded studies are outlined in Table 3.

Study Characteristics

The nine included studies comprised a mix of experimental (animal) and clinical (human) designs. Four studies utilized animal models (canine and porcine) to investigate hemodynamic responses to acute PE, while five studies involved human populations, including prospective, retrospective, and randomized controlled trials (Belenkie et al., 1989; Ferrari et al., 2022; Ghignone et al., 1984; Mercat et al., 1999; Molloy et al., 1984; Mortensen et al., 2020; Nguyen et al., 2021; Schouver et al., 2017; Ternacle et al., 2013). Sample sizes ranged from 8 to 122 participants, with animal studies generally involving smaller cohorts (Belenkie et al., 1989; Ghignone et al., 1984; Molloy et al., 1984; Mortensen et al., 2020). Human studies primarily focused on patients with massive or sub-massive PE, with several comparing FR to alternative management strategies, including DT and vasopressor support (Ferrari et al., 2022; Mercat et al., 1999; Nguyen et al., 2021; Schouver et al., 2017; Ternacle et al., 2013).

Interventions varied across studies, including isolated FR, comparisons between FR and DT, and comparisons between FR and vasoactive agents such as noradrenaline. Outcomes assessed included hemodynamic parameters, RV function, biomarker changes, and adverse clinical events. Animal studies primarily informed physiological mechanisms, while human studies contributed to clinical and outcome-based findings.

Hemodynamic Effects of Fluid Resuscitation

Across both experimental (animal) and clinical (human) studies, FR was consistently associated with increased RV preload, filling pressures, and overall hemodynamic burden (Belenkie et al., 1989; Ghignone et al., 1984; Molloy et al., 1984; Mortensen et al., 2020).

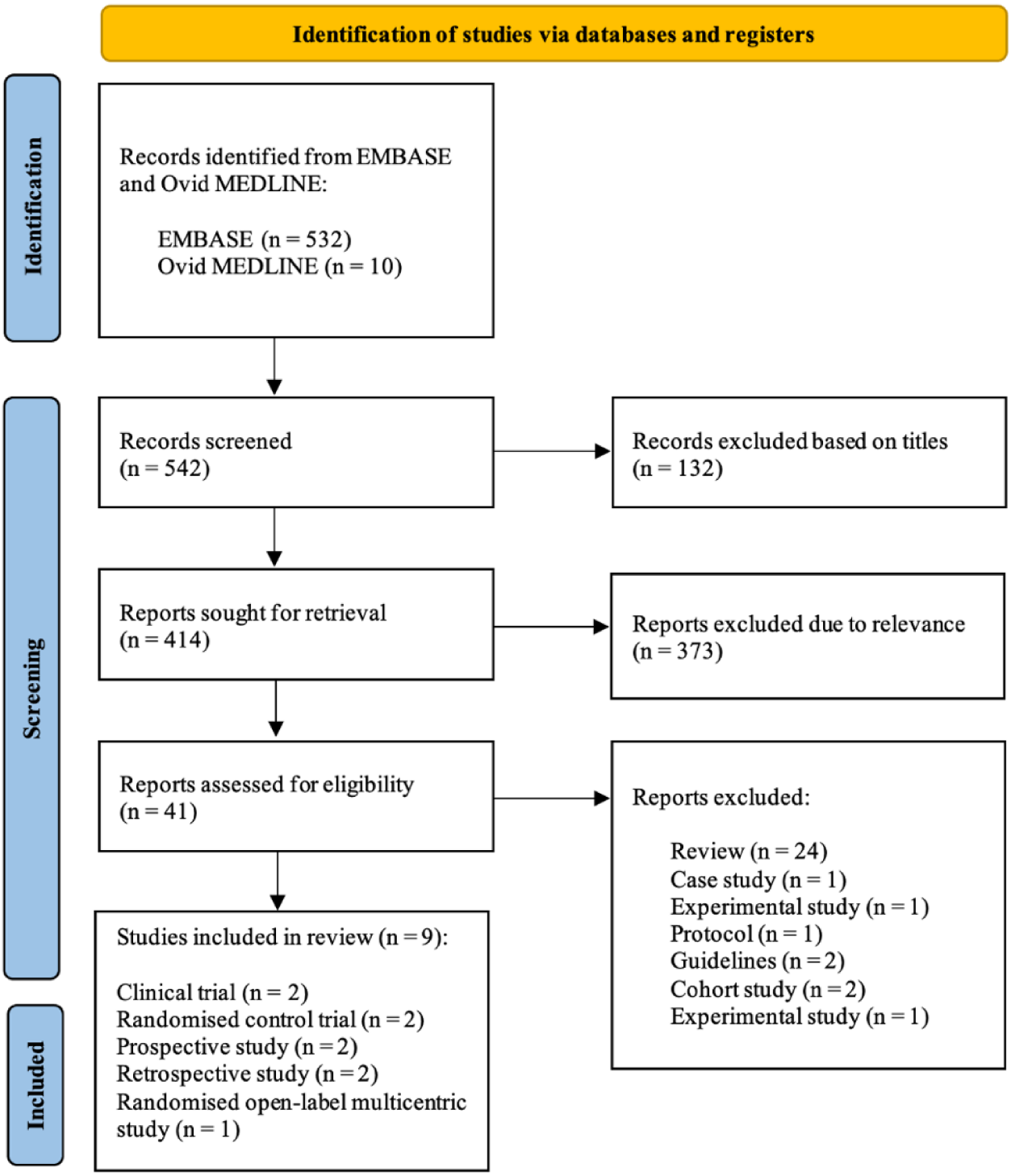


Figure 1. PRISMA flow diagram of retrieved included and excluded studies.

In animal models, FR increased left ventricular (LV) filling prior to embolization; however, following repeated embolic events, reductions in LV stroke work and cardiac output were observed (Belenkie et al., 1989).

In human studies, FR resulted in increases in right atrial pressure and RV end-diastolic volume, with only transient improvements in cardiac output reported (Mercat et al., 1999). These findings indicate that while FR may initially augment preload, this effect is not sustained in the setting of PE.

Author (Year)	Population [Sample Size]	Study Design / Intervention	Key Findings	Limitations
Belenkie et al. (1989)	Animal (canine) [n = 10]	Experimental FR (200–600 mL Ringer's lactate–blood mixture)	FR increased LV stroke work prior to embolization (188 to 260 mm Hg mm ; p < 0.05). Following embolization, FR resulted in reduced LV area index and stroke work (133 to 45 mm Hg mm ; p < 0.001), with septal shift consistent with RV dilatation and impaired LV filling.	The use of an animal model limits applicability to human physiology. Experimental conditions involving anesthesia and mechanical ventilation may have influenced hemodynamic responses. The study reflects acute changes only, and the fluid type is not standard in clinical practice.
Ferrari et al. (2022)	Human [n = 60]	Randomized controlled trial DT versus FR	FR was associated with slower normalization of BNP compared to DT (108 vs 56 hours; p = 0.05). DT resulted in faster biomarker reduction and greater early improvement (42% vs 12%; p < 0.001), with no deterioration in RV function.	Outcomes were primarily based on biomarkers rather than clinical endpoints. Potential allocation bias and patient heterogeneity may have influenced results.
Ghignone et al. (1984)	Animal (canine) [n = 8]	Experimental Dextran FR versus noradrenaline	FR increased SV and BP prior to embolization but resulted in reduced SV (9.1 to 6.3 mL; p < 0.01), decreased BP (97 to 65 mmHg; p < 0.05), and increased RV filling pressures following embolization, consistent with RV failure. Noradrenaline improved SV (6.2 to 11.3 mL; p < 0.01) and reduced filling pressures.	The small sample size increases the risk of statistical variability. The animal model and induced embolization may not accurately reflect human PE. Anesthesia and controlled ventilation may have influenced cardiovascular responses.
Ghignone et al. (1984)	Animal (canine)	Experimental Dextran FR versus noradrenaline	FR increased SV and BP prior to embolization but resulted in reduced SV (9.1 to 6.3 mL; p < 0.01), decreased BP (97 to 65 mmHg; p < 0.05), and increased RV filling pressures following embolization, consistent with RV failure. Noradrenaline improved SV (6.2 to 11.3 mL; p < 0.01) and reduced filling pressures.	The small sample size increases the risk of statistical variability. The animal model and induced embolization may not accurately reflect human PE. Anesthesia and controlled ventilation may have influenced cardiovascular responses.
Mercat et al. (1999)	Human [n = 13]	Prospective observational FR (500 mL dextran)	FR increased right atrial pressure (9 to 17 mmHg) and RV end-diastolic volume (123 to 150 mL/m ; p < 0.05). Cardiac index increased transiently (1.6 to 2.0 L/min/m ; p < 0.05), with no sustained improvement in RV function or pulmonary vascular resistance.	The small sample size and absence of a control group limit interpretation. Only a single FR bolus was assessed, and the fluid type used is not standard in current clinical practice.
Molloy et al. (1984)	Animal (canine) [n = 24]	Randomized controlled trial Control, FR (dextran), isoproterenol, noradrenaline	FR did not improve hemodynamic stability or survival. Noradrenaline improved BP and RV perfusion, with all animals in the noradrenaline group surviving compared to no survivors in the FR and control groups (p < 0.01).	The use of an animal model limits generalizability to human patients. Variability in animal size and experimental conditions may have influenced hemodynamic responses.
Mortensen et al. (2020)	Animal (porcine) [n = 22]	Randomized controlled trial FR versus DT versus control	FR increased RV end-diastolic volume (31 mL; p = 0.004), CO (approximately 2 L; p = 0.002), and RV ejection fraction (p = 0.032). DT reduced RV preload and pulmonary pressures and increased RV contractility despite reduced filling volumes.	The use of a porcine model limits translation to human physiology. Experimental conditions may not reflect clinical practice, and findings may not be directly applicable to patient care.

Table 2. Summary of included studies.

Note: Abbreviations: BNP: B-type natriuretic peptide; BP: blood pressure; CO: cardiac output; DT: diuretic therapy; LV: left ventricle; LVEDV: left ventricular end diastolic volume; MAP: mean arterial pressure; PAP: pulmonary artery pressure; PVR: pulmonary vascular resistance; RV: right ventricle; RVEDP: right ventricular end-diastolic pressure; RVEDV: right ventricular end-diastolic volume; RVD: right ventricular dysfunction; RVEF: right ventricular ejection fraction; RVSP: right ventricular systolic pressure; sPESI: simplified pulmonary embolism severity index; SV: stroke volume; SVR: systemic vascular resistance; TnI: troponin I; VE: volume expansion.

Levels of evidence are consistent with the National Health and Medical Research Council (NHMRC) guidelines (NHMRC, 2009).

Author (Year)	Population [Sample Size]	Study Design / Intervention	Key Findings	Limitations
Nguyen et al. (2021)	Human [n = 122]	Retrospective FR	Increasing FR volume was associated with a higher likelihood of adverse events, with an odds ratio of 2.1 per liter (95% CI 1.4–3.2). Overall, 41% of patients experienced complications, suggesting a dose–response relationship.	The retrospective design introduces potential bias and confounding. The absence of control group limits comparison, and patient heterogeneity may have influenced outcomes.
Schouver et al. (2017)	Human [n = 46]	Prospective DT versus FR	FR was associated with slower biomarker normalization. DT resulted in faster normalization of BNP and troponin (67.5 vs 111.6 hours; p = 0.006) and improvements in HR and RV function. No significant difference in major clinical outcomes was observed at short-term follow-up.	The small sample size and non-randomized design limit generalizability. Short follow-up duration restricts assessment of longer-term outcomes.
Ternacle et al. (2013)	Human [n = 70]	Retrospective DT versus FR	FR was associated with less favorable hemodynamic profiles. DT improved SBP, reduced shock index, improved renal function, and reduced oxygen requirements compared to FR.	The retrospective design introduces potential bias and confounding. Baseline differences between groups may have influenced outcomes.

Table 2 (continued). Summary of included studies.

Source	Reason for Exclusion
Aggarwal (2017)	Review article; did not specifically address fluid resuscitation in PE.
Banerjee and Mora (2020)	Review article; provided clinical overview without primary data on fluid therapy.
Becattini et al. (2016)	Systematic review; focused on mortality risk associated with DVT rather than fluid therapy.
Belenkie et al. (1988)	Experimental study; examined baseline cardiac function without evaluating fluid resuscitation effects.
Belohlávek et al. (2013)	Review article; discussed volume expansion broadly without PE-specific fluid therapy data.
Chatterjee et al. (2014)	Meta-analysis; focused on thrombolytic therapy rather than fluid management.
Chopard et al. (2022)	Review article; general overview of PE without specific analysis of fluid therapy.
Cruz et al. (2023)	Literature review; focused on interventional and surgical PE management strategies.
Dal et al. (2024)	Review article; discussed general treatment approaches without specific fluid therapy data.
Dudzinski et al. (2017)	Review article; focused on interventional therapies, not fluid resuscitation.
Febra et al. (2024)	Review article; focused on diuretic therapy without comparison to fluid resuscitation.
Fernandes et al. (2019)	Review article; general overview without primary data on fluid therapy.
Gallet (2015)	Protocol paper; described study design without reported results.
Group (2016)	Observational study; focused on post-resuscitation outcomes in cardiac arrest rather than fluid therapy in PE.
Harvey et al. (2022)	Systematic review; examined catheter-directed therapies, not fluid management.
Hao et al. (2015)	Systematic review; focused on thrombolysis rather than fluid therapy.
Hussain et al. (2024)	Review article; focused on RV function without fluid therapy data.
Jaff et al. (2011)	Guideline document; provided management recommendations without primary data.
Kasper et al. (1997)	Cohort study; focused on thrombolysis and diagnostics rather than fluid therapy.
Konstantinides et al. (2019)	Guideline document; provided recommendations without primary research data.
Martinez Licha et al. (2020)	Systematic review; focused on interventional and surgical management strategies.
Meyer et al. (2016)	Narrative review; discussed volume loading without primary experimental data.
Moorjani and Price (2013)	Review article; focused on endovascular and interventional management.
Pérez-Nieto et al. (2023)	Review article; discussed fluid management conceptually without primary data.
QiMin et al. (2020)	Retrospective study; focused on anticoagulation and interventional therapies rather than fluid resuscitation.

Table 3. Summary of excluded studies.

Abbreviations: AIS: Acute Ischemic Stroke; COVID-19: Coronavirus Disease 2019; DVT: Deep Vein Thrombosis; LV: Left Ventricular; PE: Pulmonary Embolism; PERT: Pulmonary Embolism Response Team; RV: Right Ventricular.

Source	Reason for Exclusion
Rali and Criner (2018)	Review article; focused on sub-massive PE management without fluid therapy analysis.
Root et al. (2018)	Review article; focused on multidisciplinary PE response teams (PERT).
Sakr et al. (2020)	Narrative review; focused on anticoagulation in COVID-19-related PE.
Silveira et al. (2024)	Case report; single patient study not generalizable.
Tapson and Weinberg (2020)	Review article; guideline-based discussion without primary data.
Vyas et al. (2024)	Review article; provided general recommendations without experimental data.
Yamamoto (2018)	Narrative review; discussed management strategies without primary data on fluid therapy.

Table 3 (continued). Summary of excluded studies.

Right Ventricular Dysfunction and Cardiac Output

Several studies demonstrated that FR contributed to worsening RV dysfunction in the setting of increased afterload (Belenkie et al., 1989; Ghignone et al., 1984; Mortensen et al., 2020). Experimental models showed that increased RV distension following FR resulted in interventricular septal shift toward the LV, impairing LV filling and reducing overall cardiac output (Belenkie et al., 1989).

In comparative studies, FR was associated with declining stroke volume (SV) and systolic blood pressure (SBP) following embolization, whereas vasopressor support improved CO and systemic perfusion (Ghignone et al., 1984; Molloy et al., 1984). Clinical data further demonstrated increasing volumes of FR were associated with hemodynamic deterioration, with a dose-dependent relationship observed between fluid administration and adverse outcomes (Nguyen et al., 2021).

Clinical Outcomes and Adverse Events

Clinical studies examining patient outcomes demonstrated limited benefits of FR. In retrospective cohorts, increasing fluid volumes were associated with higher rates of adverse events, including hemodynamic instability (Nguyen et al., 2021).

In contrast, studies comparing FR to DT reported improved biomarker profiles and hemodynamic parameters in patients receiving DT (Ferrari et al., 2022; Schouver et al., 2017; Ternacle et al., 2013). Faster normalization of biomarkers such as B-type natriuretic peptide (BNP) and improvements in heart rate and SBP were observed in DT groups, although differences in major clinical outcomes were not consistently demonstrated.

Alternative Management Strategies

Alternative strategies, including DT and vasopressor therapy, were evaluated across several studies. DT was associated with reductions in RV preload, improved hemodynamic parameters, and enhanced renal function (Ferrari et al., 2022; Mortensen et al., 2020; Schouver et al., 2017; Ternacle et al., 2013).

Vasopressor therapy, particularly noradrenaline, in experimental models improved SBP, RV perfusion, and overall CO (Ghignone et al., 1984; Molloy et al., 1984). Improved survival was observed in vasopressor-treated groups compared to those receiving FR (Molloy et al., 1984).

DISCUSSION

This review examined the role of FR in the management of MPE, with a focus on its hemodynamic effects and implications for prehospital care. Across the limited available evidence, FR was associated with increased RV preload but little sustained hemodynamic benefit (Belenkie et al., 1989; Mercat et al., 1999; Mortensen et al., 2020). While transient improvements in CO have been reported, these effects were not consistently sustained and occurred alongside evidence of RV dysfunction and dilatation (Mercat et al., 1999; Nguyen et al., 2021). Observational data also suggest an association between increasing fluid volumes and adverse clinical outcomes (Nguyen et al., 2021). However, these findings should be interpreted cautiously. The evidence base is small and heterogeneous, comprising experimental animal models and observational human studies, with some clinical evidence derived from patients with intermediate risk rather than massive PE. No included studies specifically examined FR in the prehospital setting.

An understanding of the underlying pathophysiology provides a plausible explanation for these findings. In MPE, hypotension primarily results from acute RV pressure overload caused by obstruction of the pulmonary vasculature rather than intravascular volume depletion (Konstantinides et al., 2019; McGuire et al., 2024). This increases RV afterload, resulting in progressive RV dilatation and interventricular septal shift, which may impair left ventricular (LV) filling and reduce CO (Bryce et al., 2019). Under normal physiological conditions, increased preload augments SV through the Frank–Starling mechanism. In MPE, however, the pressure-overloaded RV may have limited capacity to accommodate additional volume. Further volume expansion may therefore exacerbate RV dilatation and ventricular interdependence without meaningfully improving forward flow (Belenkie et al., 1989; Ghignone et al., 1984). This provides a physiological rationale for why responses to FR in MPE may differ from those observed in hypovolemic shock.

The limited clinical evidence is broadly consistent with this physiological rationale. Although FR may produce short-term increases in CO, available studies have not demonstrated sustained hemodynamic or clinical benefit (Mercat et al., 1999). Increasing fluid volumes have also been associated with worsening hemodynamic profiles and markers of RV dysfunction (Nguyen et al., 2021). These associations do not establish causation, and the limited observational evidence precludes firm conclusions regarding optimal fluid volumes in MPE. Nevertheless, the findings raise concern that indiscriminate volume loading may be poorly suited to a condition characterized predominantly by acute RV pressure overload rather than volume depletion.

Limited evidence has also explored hemodynamic strategies other than volume expansion. Studies examining DT have reported reductions in RV preload and improvements in selected hemodynamic and biomarker parameters (Ferrari et al., 2022; Mortensen et al., 2020; Schouver et al., 2017; Ternacle et al., 2013). However, these findings should not be interpreted as supporting routine diuretic therapy in MPE, particularly in the prehospital setting. The available studies are limited by their design, setting and patient populations, and the safety and clinical benefits of prehospital DT remain uncertain. Rather, these findings reinforce the potential importance of avoiding unnecessary volume loading and highlight the need for further investigation of strategies that target RV dysfunction and systemic perfusion.

Vasopressor therapy, particularly noradrenaline, has demonstrated improvements in SBP and CO in experimental models without increasing venous return or RV wall stress (Ghignone et al., 1984; Molloy et al., 1984). Physiologically, maintaining systemic and coronary perfusion pressure may support RV function in the presence of increased pulmonary vascular resistance (McGuire et al., 2024). However, much of this evidence is experimental, and its direct applicability to prehospital patients with MPE remains uncertain. Further clinical research is required before comparative conclusions can be drawn regarding vasoactive therapy and FR in this population.

These findings have important implications for prehospital care but should be interpreted within the limitations of the available evidence. Paramedics frequently encounter hypotension, for which FR may be considered as an initial intervention. In suspected MPE, however, hypotension may reflect acute RV pressure overload rather than intravascular volume depletion. The available evidence therefore supports caution against indiscriminate or unnecessary volume loading rather than establishing the superiority of an alternative treatment strategy. Current evidence is insufficient to support routine prehospital diuretic therapy, and further research is required to determine optimal fluid strategies and evaluate alternative hemodynamic approaches, including vasoactive medications, in patients with MPE.

LIMITATIONS

Several limitations should be considered when interpreting the findings of this review. First, a substantial proportion of included studies utilized animal models. While these designs allow controlled hemodynamic experimentation, they may not fully replicate human cardiopulmonary physiology. Experimental conditions frequently involved anesthesia or mechanical ventilation, both of which may influence hemodynamic responses and limit translation to clinical practice.

Second, many studies were limited by small sample sizes, absence of control groups, and reliance on surrogate biochemical markers rather than patient-centered clinical outcomes. These factors reduce statistical power and limit generalizability. Variability in fluid type (e.g., Ringer's lactate, Dextran 6%) and administration protocols further reduced comparability across studies.

Third, several included studies were retrospective in design, introducing potential selection bias and confounding. Follow-up durations were often short, preventing assessment of longer-term outcomes. Notably, there is a lack of prehospital-specific research, resulting in a significant evidence gap in the paramedic management of PE-associated hypotension.

Future research should focus on prospective clinical studies evaluating hemodynamic management strategies in patients with MPE, particularly in prehospital settings. Studies examining patient-centered outcomes, standardized fluid protocols, and early vasoactive strategies would strengthen the evidence base and better inform clinical practice.

CONCLUSION

This narrative review examined the role of FR in the management of MPE, with a focus on its hemodynamic effects in the acute setting. The available evidence demonstrates

that FR is associated with worsening RV dysfunction and dilatation, reduced CO, and hemodynamic instability. These findings are consistent with the pathophysiology of MPE, where acute increases in RV afterload impair ventricular filling and limit effective CO. Observational human data also suggests that increasing fluid volumes are associated with adverse clinical outcomes. While the evidence for hemodynamic compromise is more consistent than that for clinical endpoints, no included study demonstrated a sustained clinical benefit from FR.

In contrast, strategies targeting RV function and systemic perfusion, including vasopressor therapy and DT, were associated with improved hemodynamic parameters. Although much of the evidence is derived from limited experimental, animal, and in-hospital settings, the findings suggest relevance to prehospital management. The available evidence supports a more targeted approach to hemodynamic management in MPE, prioritizing strategies that address RV failure rather than routine volume expansion. Further research is required to determine the optimal hemodynamic management of PE in the prehospital setting and inform the development of evidence-based clinical guidelines, with potential for changes to future clinical practice.

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CASE REPORTS

PENETRATING ABDOMINAL INJURY IN PREHOSPITAL CARE: EXPECTATIONS AND LIMITATIONS RELATED TO CURRENT TREATMENT GUIDELINES IN POLISH EMERGENCY MEDICAL SERVICES SYSTEM PRESENTED AS A CASE REPORT

Przemyslaw Kluj, PhD, EMT-P*[1,2]; Paweł Guzik[1]; Krystyna Frydrysiak, MD[3]; Paweł Ratajczyk, MD[1]; Tomasz Gaszyński, MD[1]

Author Affiliations: 1. Department of Anesthesiology, Intensive Care, and Pain Management, Medical University of Łódź, Łódź, Poland; 2. National EMS Agency, Łódź, Poland; 3. Emergency Medicine and Disaster Medicine Department, Medical University of Łódź, Łódź, Poland.

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*Corresponding Author:
przemyslaw.kluj@umed.lodz.pl

ABSTRACT

Introduction: Among multiple organ trauma, abdominal injuries occupy a special place, as they are associated with a high risk of severe complications and frequently require careful prehospital treatment and urgent surgical intervention. This type of injury carries a high risk of damage to the organs located not only in the abdominal cavity but also in the chest – depending on the angle of penetration. This increases the risk of complications during treatment. One of the modern methods used in the prehospital care to control bleeding is tranexamic acid, which has been used for years in other clinical settings. Taking into account the variety of treatment protocols, the indications for its use deserve a broader perspective in prehospital care.

Methods: We performed detailed description of a case study of a 60-year-old woman with a penetrating abdominal injury resulting from a self-inflicted stab wound with suicidal intent. We also describe the treatment implemented in prehospital care with tranexamic acid administration and the use of a non-obvious method of immobilization of a foreign body in an existing wound.

Aim: The aim of our study was to evaluate the prehospital management of a woman with a penetrating abdominal injury, with particular attention to the administration of tranexamic acid and improvised method of foreign body immobilization.

Findings: The prehospital treatment described in this paper enabled the inhibition of the progression of hypovolemic shock, securing the foreign body in the wound and safe transport of the patient to the trauma center, where she was admitted in a stable condition.

Conclusion: Efficient teamwork, proper immobilization of the foreign body and appropriate, targeted medication administration enabled the patient's safe transport to the hospital. In this particular case, prehospital administration of tranexamic acid and restrictive fluid resuscitation did not worsen the patient's condition.

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INTRODUCTION

Traumatic injuries represent a major global public health problem and remain one of the leading causes of death and disability, especially in people under 30 years old (World Health Organization [WHO], 2024). In prehospital care, trauma accounts for a considerable proportion of emergency medical services (EMS) interventions, frequently requiring rapid assessment, early recognition of life-threatening conditions, hemorrhage control, and rapid transport to specialized trauma centers.

In Poland, a small mid-Eastern European country with 38 million citizens, over 1 million patients with traumatic injuries are admitted to emergency departments (ED) each year (Sanak et al., 2025). Among all, abdominal injuries are present in roughly 36-53% of the cases (Kopta et al., 2026; Kuli et al., 2007; Sulej-Niemiec et al., 2024). Abdominal trauma can be subcategorized into 2 types: blunt and penetrating. The vast majority are blunt injuries (approximately 80%), whereas penetrating injuries constitute about 20% of cases.

Penetrating abdominal trauma in the Polish setting occurs less frequently than in countries with a higher prevalence of firearm related violence; nevertheless, it remains a significant diagnostic and therapeutic challenge. The most common mechanisms include stab wounds and, much less frequently, gunshot wounds. However, compared with blunt trauma, penetrating injuries are more often associated with interpersonal violence and carry a higher risk of direct damage to multiple internal organs. The estimated overall mortality for abdominal trauma in Poland ranges from 5% to 10% and may be considerably higher in the most severe cases (Brongel, 2003; Kopta et al., 2026; Kuli et al., 2007). At the same time, the absence of a comprehensive national trauma registry limits the ability to precisely assess the true incidence, mechanisms, and treatment outcomes of penetrating abdominal injuries.

The priority in prehospital care after initial stabilization of the patient, which includes airway management, oxygenation, establishing circulatory access, pain relief, and fluids administration, is rapid transport to the hospital, as approximately one-third of stab wound cases require urgent surgical intervention (Brongel, 2003; Kasperczak et al., 2025). At the same time, external and internal bleeding control is crucial. To achieve this goal, the wound should be appropriately dressed, and the foreign body should be immobilized if it is still present. According to the latest Prehospital Trauma Life Support (PHTLS), Tactical Combat Life Support (TCCC), and International Trauma Life Support (ITLS) recommendations that we follow in the Polish EMS system, tranexamic acid (TXA) should also be considered, as it reduces the intensity of bleeding when administered in specific time frame (Campbell & Alson, 2020; National Association of Emergency Medical Technicians [NAEMT], 2023). On the other hand, TXA administration principles remain inconsistent when we take into account other clinical areas and specific groups of patients. This article highlights the success of using TXA in controlling active bleeding in a 60-year-old woman with a penetrating abdominal injury. Moreover, we present our point of view on the prehospital use of TXA upon the specific case study and undertake the attempt to develop a structured framework using the principles of TXA use in the prehospital environment.

METHODS

The political and economic transformation after 1989 initiated major reforms in the Polish healthcare system. A major milestone occurred in 2006 with the "Act on State Emergency Medical Services" that formally stated the recognition of emergency medicine as a medical specialization and paramedicine as an independent healthcare profession (Act of 8th September 2006 on State Emergency Medical Services [Journal of Laws], 2006). This significantly changed the structure of prehospital care and created multiple roles for the new paramedic profession in critical care to include among others: advanced life support, advanced instrumental airway management (enabling intubation in cardiac arrest episodes), prehospital ECG transmission, and specific medication administration. This represented a transition from a purely physician-centered system toward a mixed physician-paramedic model.

In the Polish EMS system, personnel are obligated to perform emergency medical procedures in accordance with the latest medical knowledge based on evidence-based medicine (EBM). There are no specific national guidelines nor specific local protocols. Therefore, personnel may utilize both American and European translated algorithms, freely, to ensure the best patient care.

To present the case accurately and in details, the trauma and "ABCDE" assessment scheme, derived from the 10th edition PHTLS course manual (National Association of Emergency Medical Technicians [NAEM], 2023) will be used. This approach is routinely applied in Polish EMS and, in summary, includes: A (Airway) – assessment of airway patency, B (Breathing) – assessment of breathing, C (Circulation) – assessment of the circulatory system, D (Disability) – neurological assessment, E (Exposure, Environment) – patient exposure, assessment of the scene of the incident, and overall evaluation of the situation. Detailed steps of the trauma examination approach are presented in Figure 1.

CASE REPORT

Around 5 p.m. in the middle of last year's autumn, a two-person EMS team was dispatched to a 60-year-old woman with a penetrating abdominal injury resulting from a self-inflicted stab wound with suicidal intent. The call was assigned the highest priority code. The response time from dispatch to arrival on scene was seven minutes. Due to the absence of a police patrol at the scene, the paramedics made an independent decision to enter the building.

Upon arrival at the scene, located on the first floor of a single-family house, the team found the woman lying in bed. At the time of the rescuers' arrival, she was calm, positioned supine.

The initial impression was poor. The woman was agitated, diaphoretic, and appeared to be under the influence of alcohol and/or medications. A knife handle measuring several centimeters was protruding from the abdominal cavity at the level of the umbilicus (see Figure 2). Small amounts of dried blood were visible around the handle, and the abdominal circumference appeared distended. The primary assessment revealed compensated hypovolemic shock resulting from the blood loss into the abdominal cavity.

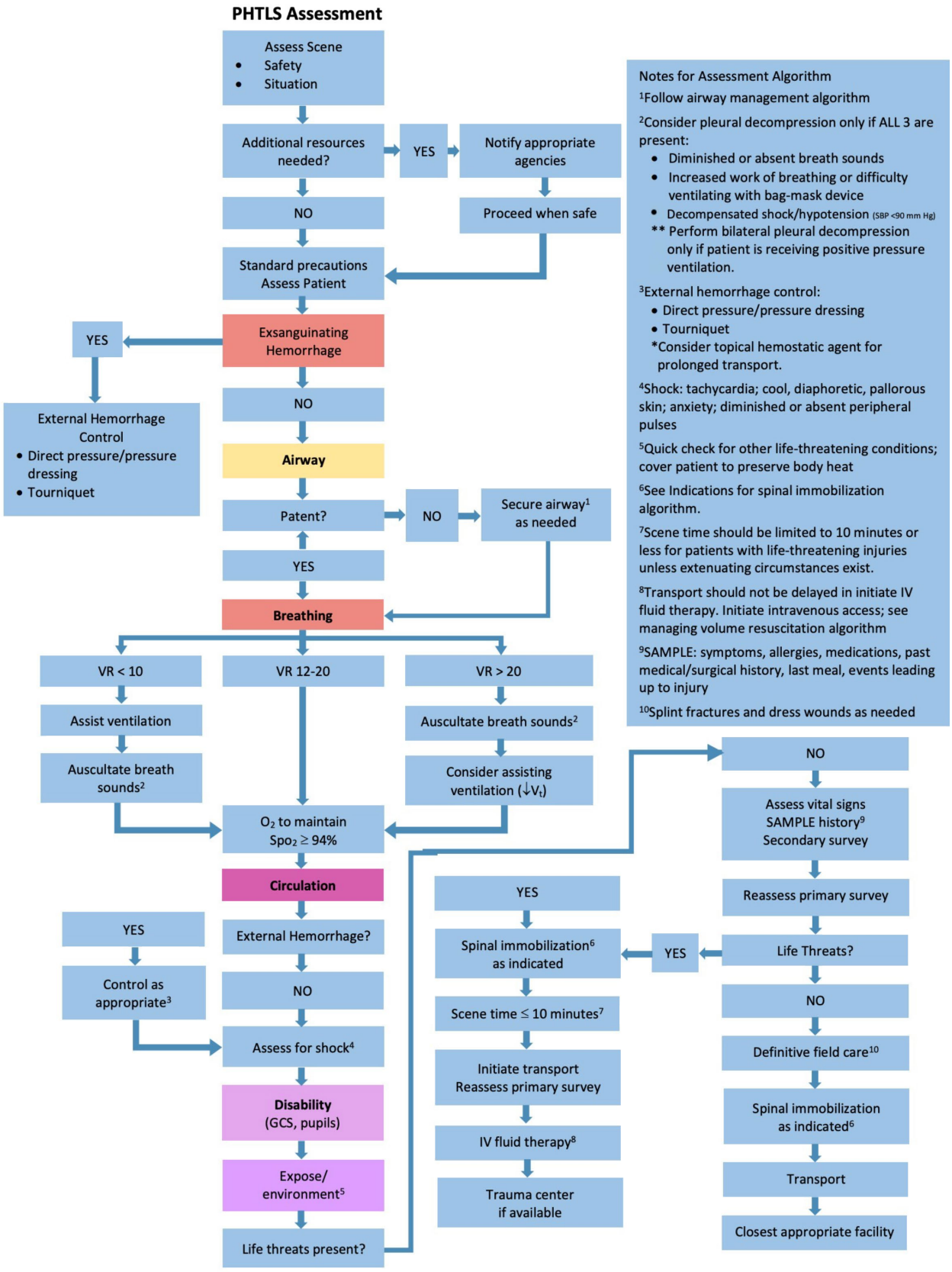


Figure 1. PHTLS examination approach.
Note: From "PHTLS: Prehospital Trauma Life Support 10th Edition," by National Association of Emergency Medical Technicians, 2023, Jones & Bartlett Learning.



Figure 2. Woman with a penetrating abdominal injury resulting from a self-inflicted stab wound with suicidal intent - photo taken during the first contact with the patient.
Note: Photograph from the author's personal collection.

Initial Assessment "ABC"

The airway was patent with no intervention required. The respiratory rate was 20 breaths per minute, SpO_2 was 98%, and bilateral vesicular breath sounds were present over all lung fields. Skin was diaphoretic and pink. A pulse was palpable on the carotid and radial arteries (peripherally thready), approximately 110 to 120 beats per minute. Blood pressure was 90/60 mmHg. Heart sounds were audible. Intravenous access was secured with a 20-gauge cannula. Capillary refill time was approximately four seconds. The blood glucose level was 113 mg/dL. Due to concerning circulatory parameters ("C") and the need to secure the foreign body within the wound, a full assessment in categories C, D, and E was deferred.

Medical Interview (Background of the Event)

The patient's father was present at the scene and had been at home with his daughter at the time of the incident. Several years earlier, the daughter had been diagnosed with par-

anoid schizophrenia, depression, and alcohol dependence syndrome. Suicidal ideation had occurred in the past but had never previously resulted in a suicide attempt. When asked about the approximate size of the knife used by the patient to inflict the injury, the father, due to strong emotional distress, was unable to specify exact dimensions but stated that the knife was "large."

For approximately one week prior to the incident, the patient had been on an alcohol binge (most commonly consuming vodka), and she had expressed suicidal thoughts and a desire to end her life for approximately three days. In the past, she had been hospitalized multiple times for her mental conditions and had been prescribed long-term medications; however, the EMS team was unable to locate these medications at the scene.

Additionally, the father reported that his daughter had previously ingested various oral medications together with alcohol and then slept continuously for several hours. He did not attempt to remove the knife from the wound, nor did he apply any form of wound management; instead, he called the emergency number 112 to obtain medical assistance for his daughter.

Both the patient and her father consistently stated that no other individuals were present at the scene and that the wound resulted from a self-inflicted stab to the abdomen. Approximately five minutes after entering the building, a unit of the Volunteer Fire Brigade arrived on scene. Upon approaching the patient, firefighters were asked to take over and gently immobilize the patient's upper limbs to prevent potential attempts to deepen the wound or remove the foreign body.

Intervention Performed After the Pre-Examination

There was no need for airway management. The patient was communicating fluently with the EMS team. Oxygen supplementation was provided via non-rebreather face mask at a flow rate of 15 L/min with an SpO_2 of 99%. Rescuers established a second intravenous line and administered a 250 mL IV bolus of 0.9% NaCl and 1g TXA as a slow IV bolus via the second IV line. Four-lead ECG monitoring was initiated. Analgesic treatment of fentanyl 100 µg IV was provided.

Implementation of the above interventions allowed for more thorough inspection of the wound, completion of a full trauma assessment, and planning of further patient management.

To immobilize the foreign body within the wound, one of the stabilizers from a spinal board was used. The opening of the stabilizer encompassed the entire protruding knife handle and allowed it to rest against the upper edge of the device, preventing potential displacement. The stabilizer was secured to the patient using an elastic bandage wrapped circumferentially around the torso. Additionally, several gauze pads were placed inside the stabilizer opening (around the protruding handle) to monitor for potential bleeding (see Figure 3).

Due to the presence of a foreign body within the abdominal cavity, which could cause further tissue penetration at any moment, the decision was made to transport the patient urgently to the hospital following initial stabilization and immobilization of the object. Unfortunately, due to the time pressure and too few hands to work at the subsequent

stages of the patient's treatment, it was not possible to capture the original, improvised method of immobilization in a photo.

Subsequent Vital Signs Obtained in the Full ABCDE Assessment

Airways remained patent with no intervention required. Respiratory rate was 18 breaths/min, SpO_2 99% on 12 L/min oxygen, and bilateral vesicular breath sounds remained present over all lung fields. Skin was pink and mildly diaphoretic. Pulse was palpable on carotid and radial arteries, approximately 105 beats per minute, consistent with monitor readings. Blood pressure was 100/70 mmHg. Heart sounds remained audible. Intravenous access remained patent. Capillary refill time was approximately 3 seconds. Due to satisfactory hemodynamic parameters, a second fluid bolus was withheld. The patient was alert with a GCS of 14 points. Blood glucose was 110 mg/dL. Pupils were equal and symmetrical. Temperature was 35.9 C. Neurological examination showed no focal deficits; however, due to alcohol intoxication, findings were not considered fully reliable.



Figure 3. Improvised method of knife stabilization – reconstruction.
Note: Photograph from the author's personal collection.

In observation, the patient had moderate obesity, was independently functioning, had no other visible injuries noted (slightly increased abdominal circumference). was under the influence of alcohol and possible influence of medications. The last hospital admission was approximately three years prior.

To minimize the risk of wound progression caused by the provisionally immobilized foreign body, the patient was placed on a rigid spinal board. Firefighters assisted with carrying the patient down the stairs and transferring her into the ambulance.

Transport, which took about 20 minutes, to the destination hospital after prior notification of the emergency department physician proceeded without complications and without signs of worsening shock. During communication with the receiving physician, preparation of group O Rh-negative blood products for the patient was suggested.

DISCUSSION

What Does the Polish Emergency Medical System Look Like?

The National EMS System (NEMS) in Poland was formally established in The Act of September 8, 2006. This legislation created a unified, nationwide framework for the provision of prehospital emergency care and defined the organizational, operational, and financing principles of the system (Dick, 2003). The Polish NEMS is mainly based on the Anglo-American model, with noticeable elements of the Franco-German model. Primarily, the NEMS combined elements of both models, yet in recent years it has been increasingly moving towards the Anglo-American model, which is due to the reduction in the number of teams including physicians, and the improvement in the qualifications and skills of paramedics, who are taking on more and more tasks in the area of patient care. Currently, the personnel consist of paramedics (85%), physicians (3%), and nurses (12%) (Mitura et al., 2026; Ramesh, Uma & Farhath, 2019). Over time, Poland increasingly shifted toward the paramedic-led model of prehospital care (85% which represents 1415 ambulances), reducing the number of physician-staffed ambulances (15%, which represents 250 ambulances) – 1665 total in 2025 all over the country (Polish Central Statistical Office, 2026). Moreover, in 2025, the Polish Chamber of Paramedics was established. Its immediate objectives include the introduction of a formal professional license for paramedics and the long-term guidance and development of the paramedic profession nationwide.

Paramedics in Poland are currently educated exclusively at the university level within a two-cycle system. After completing a three-year undergraduate program, they obtain a bachelor's degree and are qualified to work in emergency ambulance teams, which enables administration of 47 medications without additional authorization (e.g., TXA, fentanyl, norepinephrine, amiodarone, adenosine, diazepam, clonazepam, midazolam). Since 2026, paramedics have also had the opportunity to continue their education through an additional two-year graduate program leading to a master's degree (Dick, 2003; Polish Central Statistical Office, 2026). Additionally, paramedics may pursue four-year, full-time doctoral studies leading to the academic degree of Doctor of Philosophy, as exemplified by the author of this manuscript. However, obtaining a doctoral degree currently does not result in an extension of professional competencies or the scope of emergency medical procedures that paramedics are authorized to perform.

Since the Polish NEMS is quite young compared to other European or global systems, it is still searching for the best organizational and clinical solutions to implement in the country. At the same time, the system trains highly skilled professionals, regarded as some of the most competent and independent paramedics worldwide.

Evidence-Based Practice Guidelines for Fluid Resuscitation & TXA Administration

Traumatic injury remains one of the leading causes of death globally, with the majority due to massive hemorrhage and head injury. Evidence-based practice guidelines have been developed for fluid management in prehospital care with an emphasis on penetrating traumatic injuries (Campbell & Alson, 2020; NAEMT, 2023; Polish Central Statistical Office, 2026). Polish emergency medicine guidelines have adopted the combined ITLS and Advanced Life Support Guidelines approach in the management of trauma, indicating the administration of a crystalloid fluid bolus (as soon as possible replaced

with blood or blood products) and hemorrhage control (Soar et al., 2021). Moreover, guidelines indicate the need to limit fluid administration to the level at which peripheral perfusion is restored, defined as sufficient fluid amounts (optimally administered in the form of 250 mL boluses of 0.9% NaCl) to restore a radial pulse or systolic blood pressure of approximately 80-90 mmHg (permissive hypotension) (Kudo et al., 2017; NAEMT, 2023). Despite structured recommendations for IV fluid resuscitation for trauma within the context of fluid type, administered volume, and clinical presentation, it should be emphasized that excessive fluid resuscitation with crystalloids can lead to acidosis and dilution of clotting factors, leading to coagulopathy and deterioration of the patient's condition (Kudo et al., 2017).

On the other hand, TXA, with its antifibrinolytic, anti-inflammatory, and anti-angiogenic properties, has been widely used in multiple clinical conditions to reduce or control bleeding, including perioperative bleeding control, postpartum hemorrhage, acute upper gastrointestinal bleeding, cardiac surgery, and orthopedic surgery. Additionally, this synthetic lysine-based fibrinolytic inhibitor has now been shown to be associated with reduced mortality after traumatic injury by reducing blood loss and transfusion rates (Barrett et al., 2025; Neeki et al., 2017) This medication is also used to stop severe bleeding on the battlefield, according to TCCC guidelines (Committee on Tactical Combat Casualty Care [CoTCCC], 2026).

TXA is generally well-tolerated. Most of its adverse effects are considered mild, such as nausea and vomiting and blurred vision, or moderate, although it is shown that high doses of TXA could lead to seizures, hypotension (occurred with rapid IV bolus administration), and may affect a theoretical risk of a significant increase in thrombotic complications (Barrett et al., 2025; Neeki et al., 2017; Soar et al., 2021). Therefore, we conducted a detailed analysis of available sources.

Studies and clinical trials on the use of TXA in emergent settings have demonstrated the life-saving effects of TXA in trauma; hence, the prehospital use of TXA has grown exponentially. In recent decades, guidelines on the prehospital use of TXA in major trauma have been published by several authoritative bodies, including the United States' National Association of EMS Physicians (Barrett et al., 2025) and the United Kingdom's National Institute for Health and Care Excellence (2023). However, the formulated dose, rate, and route of administration of TXA in hemorrhagic trauma have yet to be established.

Current guidelines suggest that TXA could be given: (1) 1g intravenous/intra-osseous (IV/IO) in the prehospital settings by EMS, followed by 1g infusion over the next 8 hours in the hospital, or (2) 2g IV/IO as infusion or slow push. It is noteworthy that prehospital TXA administration is recommended to be given within a 3-hour window since the injury for hemorrhagic shock. This time frame, derived from the Clinical Randomization of an Antifibrinolytic in Significant Hemorrhage (CRASH-2) trial, has not been replaced or challenged (Shakur et al., 2010). A randomized controlled trial conducted by Ali et al. (2026) in 2025 showed that the risk of 28-day mortality increases with increasing time to the first dose of TXA, with the benefit being most pronounced within 90 minutes. Another clinical trial by Mazzei et al. (2024) demonstrated that prehospital use of TXA reduces mortality by 22% when administered at 1 g. Furthermore, a 2024 meta-analysis by Fouche et al. (2024) on the use of TXA for traumatic injury found that, in addition to

a significant reduction in mortality, there is no evidence of adverse vascular occlusive events attributable to TXA.

Various doses and regimens have been proposed in clinical trials, including single bolus, repeated bolus, and bolus plus infusion; however, the optimal dosing recommendation proposed by ITLS and PHTLS committees in the prehospital context is 1 g of TXA in 100 mL 0.9% NaCl given IV over approximately 10 minutes (slow infusion to reduce risk of hypotension) (Campbell & Alson, 2020; NAEMT, 2023). Based on the existing literature, there is insufficient evidence to support improvement in clinical outcomes from the first dose of TXA administered beyond the 3-hour window recommended by guidance.

Consistent with adult trauma principles, in pediatric trauma patients with suspected significant hemorrhage or signs of hemorrhagic shock, early administration of ideally within 3 hours of injury is emphasized. The recommended pediatric dosing is 15-20 mg/kg IV (maximum 1 g), administered slowly to minimize the risk of hypotension (Gendler et al., 2023). Although high-quality randomized pediatric trauma trials remain limited, available observational data and extrapolation from adult studies support the safety of TXA in children, with no demonstrated increase in thromboembolic complications at standard trauma dosing. Consequently, current PHTLS & ITLS guidance supports weight-based TXA administration in both groups of patients when clinically indicated, as part of early damage-control resuscitation strategies (Campbell & Alson, 2020; NAEMT, 2023). For this reason, local institutions responsible for medical supervision should familiarize themselves with the current literature and incorporate the principles of appropriate TXA use into prehospital protocols as it was done in Polish NEMS. Tranexamic acid was introduced locally into clinical use in 2023. Initially, before administering the medication, paramedics were required to contact the medical director (emergency medicine physician) of their ambulance service, describe the patient's condition, and obtain approval from a specialist available on call 24/7. After several months of successful nationwide use of TXA without reported complications, the government decided to formally expand paramedic competencies, allowing independent administration of TXA (norepinephrine administration via infusion pump was added as a second medication within the same decision) without additional authorization starting in March 2024.

LIMITATIONS

This study has several limitations. Only one case was evaluated, therefore general conclusions cannot be drawn based on the conducted study. The absence of an ultrasound device in the EMS equipment prevented the extension of diagnostics with imaging (POCUS/FAST). The lack of a dedicated method for immobilizing foreign bodies in the abdominal cavity prolonged and complicated patient management at the scene. The lack of blood products in the standard ambulance equipment forces the administration of synthetic fluids. Measuring lactate levels to assess the development of shock in Polish NEMS is not available. Additionally, lack of any feedback from the hospital treatment or further outcomes is a substantial weakness of the paper that makes the story incomplete.

CONCLUSION

Despite its many strengths, the Polish NEMS still requires further organizational improvements to better respond to evolving conditions, and technological advancements.

The introduction of clear standards and a more efficient organizational framework will enhance operational effectiveness and contribute to improving the overall quality of EMS. Even though in our case study the administration of TXA turned out to be successful, further research or clinical trials are needed to evaluate and address this clinical context.

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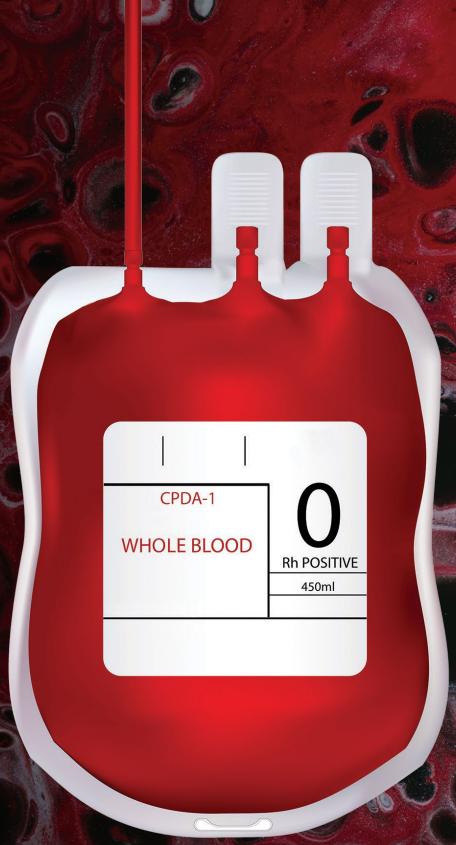
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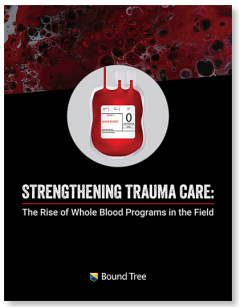


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SPECIAL REPORTS

QUALITATIVE INVESTIGATION OF EMS PROVIDER EXPERIENCES WITH A FLOW-REGULATING SAFETY DEVICE FOR MANUAL VENTILATION: A PRELIMINARY REPORT

José G. Luiggi-Hernández, PhD, MPH*[1]; James J. Menegazzi, PhD[1]

Author Affiliations: 1. University of Pittsburgh, Pittsburgh, PA, USA.

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**Corresponding Author:* jgl58@pitt.edu

ABSTRACT

Background: Over-ventilation during bag-valve-mask (BVM) ventilation (and manual ventilation in general) is a well-documented hazard in prehospital emergency care. It is associated with increased intrathoracic pressure, reduced cardiac output, gastric insufflation, and decreased survival in cardiac arrest and traumatic brain injury. The Sotair® (SafeBVM Corp., Boston, MA), is a flow-regulating safety device (FRSD) designed to prevent over-ventilation by limiting tidal volume during manual ventilation. Despite its potential clinical utility, provider-level experiences with the device in the real-world EMS clinical settings remain unreported.

Objective: We sought to explore experiences of EMS providers using the Sotair® device in clinical and training settings, with attention to perceived usability, clinical outcomes, barriers to consistent use, and recommendations for improvement.

Methods: Seven semi-structured interviews were conducted with EMS providers (EMTs, paramedics, training officers, and rescue chiefs) who have used the FRSD clinically. Interviews were analyzed using standard rapid thematic analysis. Thematic saturation was assessed iteratively and confirmed by convergence across all seven interviews.

Results: Six themes emerged: (1) Device Understanding and Simplicity: all participants described the device as intuitive, and required minimal training; (2) Training Value: the device demonstrated unexpected utility as a training instrument, with novice providers who trained with the device outperformed experienced peers on a ventilation feedback platform, with retained technique after device removal; (3) Clinical Experiences: primary use was cardiac arrest; participants reported anecdotal improvements in ROSC rates and reductions in gastric insufflation; (4) Cognitive Load Reduction and Anxiety Management: participants described reduced mental burden during resuscitation, freeing attention for scene management; (5) Barriers to Consistent Use: forgetting to deploy the device, resistance from experienced providers, cost concerns, and uncertainty in specific clinical scenarios (head trauma, drowning, pediatric patients) were identified; (6) Recommendations: pre-integration with BVM was endorsed by all participants; additional recommendations included a pediatric version, peer-to-peer marketing, and usage tracking research.

Conclusions: EMS providers reported favorable experiences with the FRSD across clinical and training contexts. The device's simplicity, cognitive load benefits, and emergent value as a training tool suggests both direct clinical and educational applications. Barriers to adoption, most notably forgetting to deploy, may be addressable through pre-implementation with standard BVM equipment.

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INTRODUCTION

Manual ventilation is a mainstay of prehospital emergency care. It is universally taught and utilized by all emergency medical services (EMS) systems, with guidance from the National Association of EMS Physicians (NAEMSP) and the American Heart Association (Carlson et al., 2022; Kleinman et al., 2025; Lyng et al., 2022). Manual ventilation is most commonly utilized with a bag-valve-mask configuration using a self-inflating bag, but it is also used when an advanced airway (endotracheal tube or supraglottic airway) has been placed. Unlike mechanical ventilation (with tightly controlled ventilatory parameters), manual ventilation is a skill that is heavily operator-dependent and often results in inappropriate ventilation being delivered.

Manual ventilation is also fraught with a variety of potentially injurious clinical and pathophysiologic conditions. These include hypoventilation, hyperventilation, barotrauma resulting in pneumothorax and/or pneumomediastinum (both of which can affect hemodynamics), gastric insufflation and aspiration, and downstream inflammation-driven lung injury. These can result in manual ventilation induced lung injury (White et al., 2024).

The NAEMSP Position Statement states: All EMS clinicians must be proficient in bag-valve-mask ventilation. EMS clinicians should use available techniques and adjuncts to achieve optimal mask seal, improve airway patency, optimize delivery of the correct rate, tidal volume, and pressure during manual ventilation, and allow continual assessment of manual ventilation effectiveness (Lyng et al., 2022). Several adjuncts for manual ventilation have been cleared by the Food and Drug Administration (FDA). Most provide visual feedback on tidal volume and peak inspiratory pressure, as well as respiratory rate. These devices have largely been studied in simulation settings (Smyth et al., 2025).

One of these FDA-cleared devices, the Sotair® (Safe BVM, Corp, Boston, MA), is a flow-regulating safety device (FRSD) for use during manual ventilation. When inspiratory pressure exceeds 55 LPM the device triggers an immediate stoppage of flow, alerting the provider that inspiratory flow, and thereby pressure, have exceeded safe limits. The feedback is tactile and auditory, rather than visual. We conducted a qualitative study of prehospital end-users of this FRSD, all of whom had used it clinically on patients.

METHODS

This study was approved by the University of Pittsburgh Institutional Review Board. We used a qualitative rapid thematic analysis design, appropriate for applied healthcare settings requiring timely, evidence-informed findings. Semi-structured interviews were conducted to allow for standardized coverage of topics, while holding space for emergent, inductive themes.

We identified three EMS agencies who were willing to participate and had been using the FRSD in their agency for at least one year. Recruitment was conducted via email distribution of a poster explaining the purposes of the study. Distribution was done through each EMS agency's Medical Director. It was made clear that the interviews would be audio-recorded for later transcription, but participation would be kept entirely anonymous. Participants must have had direct clinical experience with the FRSD. Recruitment was constrained by the occupational demands of prehospital providers, which

is common in research with this population (Leonard et al., 2012; Newington & Metcalfe, 2024). Yet, a sample of seven was deemed sufficient given the study's narrow, homogeneous population. All participants shared professional training, scope of practice, and direct clinical experience with the device. Thematic saturation was assessed iteratively, as no new themes emerged in subsequent interviews, confirming adequate informational power consistent with established qualitative standards (Guest et al., 2006; Malterud et al, 2016). Participants were paid 100 USD by prepaid card for completing the study.

Interviews were conducted by a study author, who is a qualitative methodologist at the University of Pittsburgh's Center for Biostatistics and Qualitative Methodology (CBQM), with no affiliation to the Sotair® manufacturer. Interviews were conducted remotely via video conference using Microsoft Teams. The interviews were conducted individually (i.e., one subject at a time) and audio-recorded with participant consent and lasted approximately 30 minutes. An interview summary template was designed using the research questions and the emerging themes from the interviews. The interviewer then listened to the interviews and summarized them using the template; this process was repeated to assure no relevant data were missed. A semi-structured interview guide explored participants' understanding of the device, device-related training experiences, clinical use, perceived benefits, barriers to use, and recommendations.

Transcripts were analyzed using rapid (Nevedal et al., 2021) thematic analysis, adapting Braun and Clarke's reflexive thematic analysis approach for applied research contexts (Braun & Clarke, 2021). Analysis transpired through the iterative review of the interview summaries to generate themes and sub-themes. Themes were reviewed against the full dataset, refined, and named. Illustration quotes were selected to represent each theme. The analyst maintained a reflectivity journal to document analytic decisions. All six themes emerged across all seven interviews.

RESULTS

Seven EMS providers were recruited from the three EMS agencies that had voluntarily agreed to participate. Participants included EMTs, paramedics, training officers, and a rescue chief, representing a range of organizational roles, agency sizes, and device exposure (Table 1).

Participant Number	EMS Role	Sotair® Field Uses	Primary Use	Secondary Uses
P1	Educator/Provider	4-5	Cardiac Arrest	Unresponsive patients with pulses
P2	Deputy Chief of EMS	3	Cardiac Arrest	None Mentioned
P3	Rescue Chief	1	Cardiac Arrest	Respiratory arrest, opioid overdoses, compromised respiratory drive
P4	Firefighter EMT	10+	Cardiac Arrest	CHF, sepsis, assisted ventilation
P5	Firefighter EMT	3	Cardiac Arrest	None Mentioned
P6	Paramedic/Training Officer	2	Assisted Ventilation	Unresponsive patients with pulses
P7	Paramedic	12-14	Cardiac Arrest	Unresponsive patients with pulses

Table 1. Self-reported EMS roles, number of field uses, and clinical uses of the Sotair® device by the seven participants.

Theme 1: Device Understanding and Simplicity

All participants demonstrated understanding of the FRSD, describing it as a flow-rate restrictor that limits inspiratory tidal volume when the provider squeezes the BVM too hard or too rapidly. Language used to describe this varied among participants. Perceived simplicity was the most recurring strength of the device endorsed by participants. Multiple participants stated that minimal training (e.g., brief explanation) was sufficient to use the device. While one participant suggested that even people without a medical background could use the device, another disagreed, saying it would take at least some medical training.

Theme 2: Training Experiences and the Device as Training Tool

Across departments, training included either a short instructional video or a video combined with hands-on, mannequin-based practice. All participants considered their current training adequate for device use. An emergent, recurring finding was the device's value as a training instrument beyond its clinical application. Among the participants, one shared how the novice providers (e.g., EMRs and firefighters with minimal bagging experience) trained with FRSD outperformed experienced peers on a ventilation feedback platform (Sotair IQ®, SafeBVM, Boston, MA). It was also reported that when the device was subsequently removed, novice providers maintained their improved ventilation technique, demonstrating skill acquisition via the FRSD exposure. A training gap that was mentioned was the mismatch between short training sessions lasting a few minutes and real-world experiences, where they might need to sustain ventilation for as much as 20 to 30 minutes.

Theme 3: Clinical Experiences

Cardiac arrest was the primary clinical context for Sotair use, as mentioned by all participants. Other uses included respiratory arrest, opioid overdose, and unresponsive patients. According to participants' experiences, reported clinical outcomes were favorable. A participant reported improvement in return of spontaneous circulation (ROSC) rates since department-wide adoption. Another described reduced gastric insufflation as observed through decreased suctioning of gastric contents. A third described smooth performance during an intubation scenario with unimpeded chest rise. Two participants identified challenging scenarios. One experienced frustration during a 30-minute transport resulting in hand fatigue when the FRSD repeatedly triggered. Another encountered a complex CHF/sepsis case with "stiff lungs" and was unsure if the device added to the difficulties experienced. Despite these cases, both participants maintained overall positive assessments of the device. A training officer described a first responder on their first cardiac arrest receiving real-time corrective feedback through the device's mechanism, demonstrating the utility for novice users.

Theme 4: Cognitive Load Reduction and Anxiety Management

A prominent, cross-cutting, and emergent theme was the reduction of cognitive load and anxiety. Multiple participants described how the device frees mental resources during a resuscitation. One participant framed this as giving providers "freedom of the mind to operate on the scene." Others reported how the device turned the ventilation task from a conscious, effortful task to a more automatic one. A training officer noted additional

benefits such as being able to delegate bagging to less experienced personnel more confidently. Differently, a participant mentioned how anxiety heightens when the restrictor activates unexpectedly, followed by reduced anxiety once the provider adjusts and gains confidence in improved technique. Another framed the device's effects as providing real-time confirmation of correct performance, fostering confidence rather than simply reducing anxiety.

Theme 5: Barriers to Consistent Use

Four barriers were identified. First and most prominent was forgetting to deploy the device. Every department reporting consistent use had independently adopted the workaround of preloading the FRSD onto BVMs during restocking. Second, resistance from experienced providers was documented across interviews. While this was mostly reported as an observation from participants working with more experienced co-workers, in one account, a paramedic with approximately 20 years of experience became frustrated with the device's restrictions, demanded its removal, and refused to use it. Third, cost was raised as a barrier by various participants. At approximately $20 per single-use device, cost was perceived as a meaningful barrier for high-volume services, though all participants indicated it would not lead them to discontinue its use. Fourth, clinical uncertainty was noted regarding head trauma (where ventilation may be indicated), drowning and pulmonary edema (where higher airflow may be needed), aspiration risk (regarding the valve trapping vomitus), and pediatric patients (no approved pediatric version currently exists).

Theme 6: Recommendations for Improvement

Pre-integration of the FRSD with BVM equipment was endorsed by all participants. Every department with consistent use had independently preloaded the device; participants recommended this be either built into the product design or at a minimum explicitly advised in training or sales material. Additional recommendations included: development of peer-to-peer testimonials from early-adopting departments, which were predicted to be more persuasive to resistant colleagues than clinical studies; systematic research on actual deployment rates to capture compliance gaps; and deployment of a pediatric sized version, given that pediatric emergencies generate heightened anxiety and that over-ventilation risks may be equal or more critical in that population.

DISCUSSION/LIMITATIONS

This preliminary report identified six themes regarding the clinical use of the FRSD. The functionality of the device appears to be well comprehended, training requirements appear to be minimal, and the device is reportedly somewhat easy to use. These findings are similar to other manual ventilation safety adjuncts and thus were not unexpected. The primary barrier to its use is forgetting to deploy it.

While the study is limited by its small number of participants, it is remarkable that thematic saturation was achieved just the same. The study is also limited in that actual clinical performance of the FRSD was not evaluated (effects on ROSC rates, gastric insufflation, etc.). The study does provide some valuable insights into what future questions remain unanswered.

CONCLUSION

EMS providers reported consistently favorable experiences with the FRSD across clinical and training contexts. The device's simplicity and cognitive load benefits support its clinical utility, while its emergent value as a training instrument – producing durable ventilation skill in novice providers – warrants recognition as a secondary application. The primary barrier to consistent deployment, forgetting to attach the device under emergency conditions, appears addressable through pre-integration with standard BVM equipment. Prospective research measuring objective ventilation parameters and patient-level outcomes is needed to confirm these preliminary findings.

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*Corresponding Author: bbuck@americanparamedics.org

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*Corresponding Author:
drbrendamorrissey@gmail.com

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International Journal of Paramedicine

Published by the National EMS Management Association (USA)

GUIDELINES FOR AUTHORS

Effective Date (supersedes all prior versions): April 14, 2026

The *International Journal of Paramedicine (IJOP)* is a forum for scholarly contributions and state-of-the-art research relevant to patient care and the growth and advancement of paramedicine, including the areas of paramedic leadership, management, education, operations, culture, professional, and clinical practice. The IJOP encourages exploration of paramedicine from diverse theoretical and practical views from all disciplines, including business and economics; the natural, basic, and applied sciences; and the humanities, social sciences, and arts. Priority will be given to submissions that use sound theoretical or conceptual frameworks, strong methodological design, and relevance to the international paramedic community. All methodologies, such as quantitative, qualitative, mixed methods, and knowledge syntheses, will be considered.

NEMSMA is a longtime collaborator with the National Association of EMS Physicians in support of *Prehospital Emergency Care (PEC)*. In continuation of that relationship, *IJOP* and *PEC* have established a collaborative relationship that will facilitate the exchange of submissions in certain circumstances, based in part on which journal may be the best fit for a particular manuscript.

SUBMISSION CHECKLIST

Authors need to register with the journal before submitting or, if already registered, can simply log in and begin the submission process.

Download the following worksheets to assist with the submission process. Complete the forms, use them to assist with the submission process, then upload them with the submission.

- Complete one of these forms per submission: IJOP Submission Info Form
- Complete one of these forms per author: IJOP Author Info Form

GENERAL GUIDELINES AND NOTES

- The *IJOP* only publishes material in English. Please use Academic English.
- The *IJOP* accepts submissions in the following categories:
  - Case Studies (≤2,000 words)
  - Concepts (≤3,000 words)
  - Correspondence / Commentary (≤1,000 words)
  - Education (≤3,000 words)
  - Empirical Investigations / Original Research (≤4,500 words)
  - Methodology (≤2,000 words)
  - Quality Improvement Project Reports (≤3,000 words)
  - Reviews / Synthesis (≤4,000 words)
  - Special Reports (≤2,000 words)
  - Toolbox (≤1,500 words)

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The word limits noted above are guidelines for the various submission types. Authors are encouraged to adhere to these guidelines and to be concise in their submissions.

- Merriam-Webster's Collegiate Dictionary (11th ed.) should be consulted for spelling.
- Contributions that explore non-clinical topics such as leadership, operations, education, professional practice, and the culture of paramedicine are strongly encouraged.
- Based on the international scope of the *IJOP*, contributions should provide a degree of generalizability and transferability to global settings and should have relevance to the *IJOP's* broad readership.
- *IJOP* discourages multiple publications derived from a single study.
- All original research submissions must have received approval from an Institutional Research Board (IRB) or Research Ethics Board (REB).
- Once a submission has been assessed for suitability by the editorial team, it will undergo a double-blind peer-review by independent, anonymized reviewers.

USE OF ARTIFICIAL INTELLIGENCE

IJOP recognizes that artificial intelligence (AI) tools are increasingly used in research, clinical education, and manuscript preparation. This policy establishes standards for the responsible, transparent, and ethical use of AI in all materials submitted for consideration in the Journal and is aligned with the policies of the International Committee of Medical Journal Editors (ICMJE, 2023; ICMJE, 2024) and the Committee on Publication Ethics (COPE, 2025).

The goal is to ensure academic integrity, patient safety, and accountability in the dissemination of paramedicine research and other scholarly content.

AI Authorship

Artificial intelligence tools, including large language models (LLMs) such as ChatGPT, Gemini, Claude, and similar systems, cannot be listed as authors or co-authors on any *IJOP* submission. Authorship requires the ability to take accountability for the work, approve the final manuscript, and respond to questions about the accuracy and integrity of the research. AI tools cannot fulfill these responsibilities. Any submission listing an AI tool as an author will be returned without review. This policy applies without exception, regardless of the extent of AI involvement in the work.

Permitted Uses of AI by Authors

AI tools may be used to assist authors in limited and transparent ways, including:

- Grammar, spelling, or stylistic editing
- Organizing or formatting reference lists (all references must be independently verified by authors against original sources prior to submission)
- Language translation for non-native English authors
- Programming support for simulations or modeling (when described in the Methods section)
- Statistical analysis or data visualization (when described in the Methods section)

AI tools may not be used to:

- Generate or fabricate data, patient information, or references
- Produce substantive portions of the manuscript, including but not limited to the introduction, results, discussion, or conclusions
- Create, alter, or enhance clinical photographs, diagnostic images, or figures without explicit disclosure and validation

- Circumvent originality or plagiarism checks
- Generate research questions, design the study, select participants, code or analyze data, or interpret findings
- Conduct literature searches that are not independently verified by the authors

Disclosure Requirements for Authors

Any use of AI tools in preparing a submission must be disclosed. The disclosure must appear in the Acknowledgements section of the manuscript and, where applicable, in the Methods section if AI was used in data collection, analysis, or figure generation. The disclosure must include:

- The name of the AI tool
- The developer and specific version or model (e.g., GPT-4o, claude-sonnet-4-6, Gemini 2.5 Pro)
- The date the tool was accessed
- A clear description of the specific purpose for which it was used
- An affirmation that the authors reviewed, verified, and take full responsibility for all AI-assisted output

Example disclosure statement:

> *Claude (Anthropic, claude-sonnet-4-6, accessed March 2026) was used to assist with sentence-level editing and language consistency across drafts. The authors reviewed all AI-assisted content, independently verified all citations against publisher and PubMed records, and take full responsibility for the accuracy and integrity of this manuscript.*

If no AI tools were used, authors must include the following statement in the Acknowledgements:

> *No generative AI tools were used in the preparation of this manuscript.*

AI in Studies Using LLMs as Research Instruments

Submissions that evaluate, benchmark, or deploy large language models as research instruments (rather than using them as writing aids) are subject to additional requirements. These submissions must:

- Specify the exact model name, version, and access date for each AI model evaluated
- Provide verbatim prompts submitted to each model in the methods section or as a supplemental appendix. Prompt text is a primary experimental variable. Studies that do not disclose it cannot be reproduced or audited and therefore will not be accepted for peer review.
- Describe the complete pipeline for hybrid or multi-step AI systems, including how outputs from one model were formatted and passed to subsequent models.
- Confirm that the study dataset was independent of any model's development or calibration data.
- Adhere to the TRIPOD+AI reporting standard (Collins et al., 2024, BMJ) and, for studies specifically deploying LLMs, the TRIPOD-LLM reporting guideline (Messaritakis et al., 2025, Nature Medicine)
- Acknowledge whether any AI tool evaluated is regulated as a Software as a Medical Device (SaMD) by the FDA or equivalent regulatory authority in the study's jurisdiction. Studies recommending clinical deployment of AI tools must document that the tool has received appropriate regulatory authorization

Note: As of 2026, the U.S. FDA has not approved any general-purpose consumer large language model for clinical diagnostic use. Studies recommending integration of such tools into clinical or prehospital workflows must acknowledge this regulatory status explicitly.

Citation Accuracy

Authors are responsible for the accuracy of all citations. AI-generated reference lists are known to contain fabricated citations at rates as high as 18–55%, depending on the model and topic area. All references must be independently verified by the authors against the original source prior to submission. The editorial team reserves the right to spot-check citations and to return submissions with unverified or fabricated references for correction prior to peer review.

AI Use by Peer Reviewers

Peer reviewers are strictly prohibited from uploading any portion of a submitted manuscript into any public-facing generative AI tool. Manuscripts submitted for review are the unpublished intellectual property of the authors. Using an external AI platform to process a manuscript violates the confidentiality obligations of peer review and may constitute a breach of intellectual property rights. Reviewers who require AI assistance for language support must use only locally deployed or institution-licensed tools that do not transmit manuscript content to external servers and must disclose this use to the Associate Editor that is managing that manuscript. Any reviewer found to have violated this provision will be removed from the *IJOP* reviewer database.

AI Use by Editors

Editors may use AI tools to assist with administrative functions such as formatting checks, metadata verification, or detecting common patterns associated with AI-generated manuscripts. Editors must not use AI tools to generate or substantially revise editorial decisions, correspondence with authors, or formal editorial assessments. All editorial decisions remain the responsibility of human editors. Editors are encouraged to attend to secondary signals associated with AI-generated manuscripts, including formulaic prose structure, hedged transition language, methodological gaps concentrated in areas of domain expertise, and citation anomalies, in addition to using automated detection tools.

Enforcement

Failure to properly disclose AI use, evidence of prohibited AI use, or submission of fabricated citations will be treated as a breach of ethical standards. Consequences may include:

- Immediate rejection or retraction
- Notification to authors' institutions or employers
- Reporting to relevant research integrity bodies

All cases involving suspected AI misuse will be handled in accordance with COPE and ICMJE guidelines. *IJOP* reserves the right to request raw prompts, model logs, or other documentation to investigate suspected misuse.

References for This Policy

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SUBMISSION ITEMS

As part of the submission process, authors will be required to confirm that their submission complies with all of the items below. Submissions may be returned that do not adhere to these guidelines.

Documents

- The submission cannot be previously published or in the submission process of another publication (or an explanation has been provided in a cover letter to the Editor).
- The Author and Funding File and the Main Submission File are all in Microsoft Word document file format (.doc or .docx).
- An ICMJE Form for Disclosure of Potential Conflicts of Interest is submitted for each author. The form is available at: https://icmje.org/disclosure-of-interest/
- All illustrations, figures, and tables should be placed within the text at the appropriate points AND submitted as separate files in a high-resolution format.
- Supplemental media files (e.g., spreadsheets, slides, audio or video files) may be included for reader access. The file should be hosted by the authors unless other arrangements have been made with the Editors.
- Where available, URLs for each reference have been provided. A DOI hyperlink is preferred.
- A completed AI use disclosure statement has been included in the Acknowledgements section (see Use of Artificial Intelligence above), either disclosing specific AI tools used or affirmatively stating that no AI tools were used.
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Manuscript

- The text is double-spaced in a 12-point font.
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- IRB or REB approval documentation is included where required, with protocol number, approving body, and determination category specified.
- Authors are strongly encouraged to follow applicable EQUATOR (Enhancing the QUAlity and Transparency Of health Research)(https://www.equator-network.org) reporting guidelines. See below for the list applicable to common study types.
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- Reporting Standards (EQUATOR Network)

The following EQUATOR reporting guidelines apply to common study designs submitted to *IJOP*. Authors should apply the guideline most appropriate to their study design and attach the completed checklist as a supplemental file. Where no single guideline applies, authors should follow the spirit of the applicable standard and consult the editorial team.

Note: A section of the EQUATOR network contains guidelines specific to emergency medicine that may also be applicable to studies in paramedicine: https://www.equator-network.org/reporting-guidelines-medical-specialty/emergency-medicine-2

Randomized trials

- CONSORT and its extensions (https://www.equator-network.org/reporting-guidelines/consort)

Observational studies

- STROBE and its extensions (https://www.equator-network.org/reporting-guidelines/strobe)

Systematic reviews and meta-analyses

- PRISMA 2020 and its extensions (https://www.equator-network.org/reporting-guidelines/prisma)

Study protocols

- SPIRIT and the PRISMA-P extension (https://www.equator-network.org/reporting-guidelines/spirit-2013-statement-defining-standard-protocol-items-for-clinical-trials)

Diagnostic and prognostic accuracy studies

- STARD (https://www.equator-network.org/reporting-guidelines/stard)

Prediction model studies (clinical AI and machine learning)

- TRIPOD+AI (Collins et al., 2024, BMJ) (https://doi.org/10.1136/bmj-2023-078378). Required for all studies developing or evaluating AI/ML prediction or diagnostic models. This guideline supersedes the 2015 TRIPOD checklist and must be used in its place for all new submissions. A completed TRIPOD+AI checklist must be submitted as a supplemental file.
- TRIPOD-LLM (Messaritakis et al., 2025, Nature Medicine) (https://doi.org/10.1038/s41591-024-03425-5). Required for studies specifically deploying large language models in healthcare settings. A 19-item checklist covering transparency, human oversight, and task-specific performance reporting. Use in addition to TRIPOD+AI for LLM studies.

Case reports

- CARE and its extensions (https://www.equator-network.org/reporting-guidelines/care)

Clinical practice guidelines

- AGREE and the RIGHT extension (https://www.equator-network.org/reporting-guidelines/agree)

Qualitative research

- SRQR and the COREQ extension (https://www.equator-network.org/reporting-guidelines/srqr)

Animal pre-clinical studies

- ARRIVE (https://www.equator-network.org/reporting-guidelines/improving-bioscience-research-reporting-the-arrive-guidelines-for-reporting-animal-research)

Quality improvement studies

- SQUIRE and its extensions (https://www.equator-network.org/reporting-guidelines/squire)

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SUBMISSION FILES

The following describes the standard submission files that should be uploaded via the Journal submission website for each manuscript. Please refer to the specific submission guidelines for each submission category for more specific instructions that may apply.

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Author Information

- All authors of a manuscript should provide their full name with up to four post-nominals and up to two organizational affiliations and titles, exactly as they should appear in the publication.
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Funding Information

- Please provide the details for any funding that supported the submitted work.
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- If a funding source was not involved: "External funding was not used to support this work."
- If the study involved AI tools that are commercial products of a funder or that create a conflict of interest, this must be disclosed explicitly in both the funding information and the ICMJE disclosure forms.

Main Submission File

To provide a high level of objectivity in the peer-review process, *IJOP* uses a double-blind process. The identities of the authors and their institutions are not revealed to the reviewers, and the identities of the reviewers are not revealed to the authors.

Due to the double-blind review process, information about the authors and their institutions should not appear anywhere in the main submission file. This includes the removal of identifying information in the properties of the Microsoft Word files submitted.

Please do not use extensive formatting. Use single spaces between sentences. Separate paragraphs with a carriage return. Do not indent the first line of paragraphs with tabs or added spaces.

Title

- Provide the suggested title for the published article. The title used for publication is subject to editorial team approval.

Abstract, Keywords, Disclosures / Conflicts, Presentations, and Acknowledgements

- Abstracts must be limited to 300 words or fewer, including section headers. Use structured abstracts when possible.
- Include between three (3) and six (6) keywords or short phrases for search optimization. The keywords paramedicine, EMS, and emergency medical services will be added by default and do not count toward the keyword limit.
- State any disclosures or conflicts for each author, in addition to the completed ICMJE Disclosure Forms. If there are no conflicts, state "None."
- Include the required AI use disclosure statement (see Use of Artificial Intelligence section above).

Primary Manuscript Body

- The primary body of the manuscript follows the abstract page. Composition varies by category; refer to category-specific descriptions for details.
- Use a minimum of formatting. Indicate heading levels by placing (H1), (H2), (H3) directly after the heading text.
- Tables should summarize large amounts of information and must be labeled sequentially and referenced in the text.
- Figures must be labeled sequentially, referenced in the text, and also submitted as high-resolution supplemental files in PDF, JPEG, TIFF, or PNG format at a minimum of 300 dpi.

References

- Use APA7 style in-text citation and endnote formatting.
- Include a hyperlink for each reference. A DOI hyperlink in the format https://doi.org/XXXXX is preferred.
- Authors are responsible for the accuracy of all references, links, and in-text citations. AI-generated reference lists must be independently verified against the original source prior to submission (see Use of Artificial Intelligence above).

Appendices

- Where applicable, appendices to the manuscript are inserted at the end of the Main Submission File.
- For submissions evaluating AI as a research instrument, verbatim prompts submitted to each AI model must be included in the Methods section or as an appendix.

ICMJE Forms for Disclosure of Potential Conflicts of Interest

- One form per author should be submitted.
- The form is available at: https://icmje.org/disclosure-of-interest

Supplemental Media Files

- Supplemental tables or figures should each be uploaded individually.
- For spreadsheets used to generate tables, upload as individual files and clearly indicate which table they are associated with.
- For studies evaluating AI systems: verbatim prompts and any model output logs relevant to the study should be included in the Methods section or as supplemental files.
- Supplemental media files (e.g., spreadsheets, slide decks, audio or video files) must be readily accessible without passwords or other restrictions.

GUIDELINES FOR CATEGORY-SPECIFIC SUBMISSIONS

Case Reports (≤2,000 words)

These manuscripts share the experience of unusual clinical presentations, circumstances, or treatment approaches. Case reports should be structured as described in the Consensus-based Clinical Case Reporting Guideline (CARE; https://www.equator-network.org/reporting-guidelines/care).

Concepts (≤3,000 words)

These papers present a specific management or clinical concept, idea, or theory and describe its practical application. If the paper presents a new concept, it may also suggest research, improvement projects, or pilot implementations. The primary manuscript body should contain:

- Introduction: Describe the problem, issue, or circumstance that the concept is intended to address, the current literature that demonstrates a gap, and any pertinent background information.
- Concept Description: Provide a description of the concept and how it can be applied, with sufficient detail of any methods or procedures, the setting, and the population to which the concept applies.
- Discussion: Include a critical review of related research and a discussion that highlights how the concept contributes to the field of paramedicine. Address limitations.

Dialogues (≤1,000 words)

The Dialogues section publishes comments and questions from readers related to previously published articles. The primary manuscript body should include:

- Subject Paper Information: Provide the title, name of the first author, and the *IJOP* issue for the paper that is the subject of the correspondence.
- The narrative of the correspondence.

Editorials (≤2,000 words)

Editorials are a venue for the expression of opinion and perspective on topics relevant to the paramedicine community. They should make clear points in a concise manner with a scholarly approach and tone. They should not be used for the presentation of data, findings, or research that has not been previously published.

Educational Methods and Processes (≤3,000 words)

These submissions explore a specific educational process, approach, or method, and discuss issues to consider in its practical application. The primary manuscript body should contain:

- Introduction: Describe the problem or circumstance addressed, relevant literature demonstrating a gap, and pertinent background information.
- Description: Describe the educational process, approach, or method and how it can be applied, with sufficient detail of methods, procedures, setting, and population.
- Discussion: Include a critical review of related research highlighting how the approach contributes to paramedicine. Address limitations.

Empirical Investigations / Original Research (≤4,500 words)

Submissions may be clinical or non-clinical. Apply the applicable EQUATOR guidelines described above. Authors may provide, or editors may suggest, that some information be provided as a supplemental file so that the main paper remains concise. Supplemental content may include data sets, images, video clips, and in-depth methodological details.

Empirical investigations on clinical topics may be forwarded to *Prehospital Emergency Care (PEC)* for initial consideration with the author's consent.

Submissions that evaluate AI tools as research instruments must comply with the full AI research instrument requirements described in the Use of Artificial Intelligence section above, including prompt disclosure, model version specification, TRIPOD+AI/TRIPOD-LLM checklist submission, and regulatory status acknowledgment.

Methodology (≤2,000 words)

This category provides deep explorations of methods used, or that may be used in research studies or improvement projects. These methods should be novel in a way that makes them of significant interest in their own right, separate from the studies in which they are utilized. The primary manuscript body should contain appropriate elements from the applicable EQUATOR guidelines.

Quality Improvement Project Reports (≤3,000 words)

IJOP acknowledges the importance of quality improvement activities and welcomes manuscripts describing improvement projects. United States regulations do not require quality improvement activities to have IRB/REB approval, but the distinction between manuscripts requiring or not requiring approval can be subtle. Manuscripts that appear to have framed a research activity as quality improvement to circumvent compliance standards will be rejected.

Authors uncertain whether their work should be submitted as quality improvement or research are encouraged to contact the editorial office. When in doubt, submission to an IRB for an independent determination is encouraged.

Quality improvement project reports should adhere to SQUIRE guidelines (http://www.squire-statement.org). With permission of the Editorial Team, authors may use other generally accepted frameworks (e.g., IHI Model for Improvement; DMAIC).

Reports should describe the process examined; the process change(s) tested; baseline performance; methods for conducting tests and evaluating results; post-intervention performance; confounding variables and balancing measures; and process change iterations. Discussions and conclusions should highlight what the external audience can learn from the experience, not only the activity's internal success or failure.

Reviews / Synthesis (≤4,000 words)

IJOP invites the submission of reviews of all types, including those with and without meta-analytic components. All submissions in this category should be consistent with the PRISMA 2020 guidelines for reporting systematic reviews (https://www.equator-network.org/reporting-guidelines/prisma/). Reviews that incorporate AI tools in the literature search or screening process must disclose this in the Methods section, specifying the tool, version, and how AI-identified sources were independently verified.

Toolbox (≤3000 words)

These submissions explain a tool or technique and describe its practical use. Where applicable, the articles may include a supplemental file or link containing the tool and a data file where the reader may try it out. The primary manuscript body should contain.

- Introduction: An overview of the type(s) of projects the tool or technique could be used for, or the specifics of the project in which it was actually used.
- Description of the Tool / Technique: An in-depth examination of the tool or technique and its mechanics. Describe how it should be applied in a clinical, operational, or administrative setting.
- Discussion: The underlying rationale for the tool or technique, why it may be favored over other options, and a critique of related methods. Include a discussion of limitations.
- Exercise: Where applicable, describe how to use the tool or technique in conjunction with a sample data set or scenario.

KEY INTERNATIONAL STANDARDS REFERENCED IN THESE GUIDELINES

- ICMJE Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals: https://www.icmje.org
- COPE Core Practices and Position Statements on AI: https://publicationethics.org
- EQUATOR Network Reporting Guidelines: https://www.equator-network.org
- TRIPOD+AI (Collins et al., 2024): https://doi.org/10.1136/bmj-2023-078378
- TRIPOD-LLM (Messaritakis et al., 2025): https://doi.org/10.1038/s41591-024-03425-5
- CRediT Contributor Roles Taxonomy: https://credit.niso.org
- U.S. FDA AI/ML Software as Medical Device: https://www.fda.gov/medical-devices/software-medical-device-samd/artificial-intelligence-software-medical-device