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REVIEW

FEEDBACK USE IN PARAMEDICINE: A SCOPING REVIEW

James Foster, BParamedicine, BNursing[*1], Stacey Todd, BParamedicine[1], Brett Williams, PhD[2,3]

Author Affiliations: 1. London Ambulance Service, London, UK; 2. Monash University, Department of Paramedicine, Frankston, VIC, Australia; 3. Applied Medical Sciences, Jordan University of Science and Technology, Jordan.

**Corresponding Author*: jfos0005@student.monash.edu

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ABSTRACT

Objective: The aim of this scoping review is to determine how feedback is used in paramedicine.

Introduction: Feedback is widely recognised as essential for clinician growth in healthcare however there is limited research on its use within paramedicine. Paramedics place high value on effective feedback and different types and methods are used depending on context.

Methods: Peer-reviewed primary research involving any type of feedback used in paramedicine was included. We searched MEDLINE, CINAHL, EMCARE, SCOPUS, and grey literature from inception to March 2023. Two authors independently screened and selected studies for full-text review. One reviewer performed data extraction. This review followed JBI methodological guidance and PRISMA extension for scoping reviews.

Results: From 413 articles 20 were included in this review (16 quantitative, 3 qualitative, and 1 mixed-methods). Feedback is generally given under the themes of professional and personal development, quality improvement, resuscitation, and education. Paramedics have a strong desire for feedback to meet personal and professional needs. However, current provisions are inadequate and compounded by existing barriers. Informal routes of feedback are sought when formal routes are inadequate despite the latter having more weighting. Feedback in resuscitation either in real-time or post-incident positively modifies paramedic behaviour to improve performance. Feedback is used in paramedic services to standardise care as part of quality improvement. Within an education setting feedback as an education tool is well received and improves confidence for future performance.

Conclusion: Paramedics display a positive attitude to receiving feedback to meet personal and professional requirements. Desires for feedback outweigh provisions compounded by existing barriers, potentially creating a paramedic wellbeing issue. Feedback is an effective tool within paramedicine in modifying behaviours either immediately or post-incident to improve clinical performance.

Keywords: Paramedic, Paramedicine, Emergency Medical Services, Feedback, Out-of-hospital

INTRODUCTION

Despite the importance of feedback within the wider healthcare system, its use in the paramedicine profession is not well documented in the literature (Eaton-Williams, Mold, & Magnusson, 2020a; Wilson, Janes, Lawton, & Benn, 2023). Paramedicine is an evolving profession with a relatively young literature base and is no longer limited to the traditional emergency ambulance setting (Eaton, Mahtani, & Catterall, 2018; Williams, Beovich, & Olaussen, 2021). Irrespective of the working environment, paramedic wellbeing is a top priority and burnout remains a significant concern (Reardon, Abrahams, Thyer, & Simpson, 2020). The provision of effective feedback should be used as a tool to address the professional and emotional requirements of paramedics, potentially improving their wellbeing (Eaton-Williams, Mold, & Magnusson, 2020b; McGuire et al., 2021). Other benefits of feedback include clinical education, clinician self-reflection leading to autonomous practice and motivating paramedics to improve care (Cash, Crowe, Rodriguez, & Panchal, 2017; Persse, Key, & Baldwin, 2002).

Feedback is the delivery of evaluative information and represents a key concept in learning and improvement (Dai, Bertram, & Chahine, 2021; Hardavella, Aamli-Gaagnat, Saad, Rousalova, & Sreter, 2017). Delivery of feedback to healthcare staff is essential for staff well-being and clinical performance through reinforcing positive and modifying negative behaviours (Burgess, van Diggele, Roberts, & Mellis, 2020). Feedback is provided formally or informally and should be reinforcing (positive) or constructive (negative) (Panneerselvam, 2018). Although the importance of reinforcing feedback is well documented, a balanced approach using constructive feedback should be provided to improve clinician competency and patient outcomes (Hardavella et al., 2017; Plunkett, 2022). A Cochrane review highlighted how audit and feedback leads to small but potentially important improvements in aligning patient care with expected clinical practice, however, this was largely focused on doctors (Ivers et al., 2012). Further key findings suggested feedback is most effective when baseline performance is poor, given by a supervisor or colleague, is repeated, given through multiple means, and includes clear goals.

Paramedics place high importance and value on effective feedback to gain clinical and emotional closure (Wilson, Howell, Janes, & Benn, 2022). Paramedics often work in small teams or as solo responders to patients in the community and by the nature of their work are often clinically isolated from the wider healthcare system. With an emphasis on reducing Accident and Emergency pressures, increasingly complex patients are being treated in the community leading to diagnostic uncertainty as they are referred to other healthcare providers or discharged from paramedic care (Blodgett, Robertson, Pennington, Ratcliffe, & Rockwood, 2021; Wilson et al., 2022). Consequently, despite paramedics often being the first medical contact for patients, the outcomes are often unknown due to minimal patient contact time and lack of formal clinical follow-up (Drennan, Blanchard, & Buick, 2021; Eaton-Williams et al., 2020a). This can lead to wellbeing issues and a missed opportunity for learning thus reinforcing the importance of feedback to validate clinical assessment and preliminary diagnoses (Koivulahti, Tommila, & Haavisto, 2020). Paramedics also use feedback to guide clinical self-reflection to improve future performance, a key aspect of essential continuing professional development requirements (Health & Care Professions Council, 2023; Thompson, Couzner, & Houston, 2020).

There are different known types and sources of feedback available to paramedics and access is dependent on context and resources. These include real-time feedback devices or through quality improvement processes retrospectively after an incident (Simone, Ana Maria, & Fernando Tobal, 2020; Wang, Su, Fan, Hou, & Chen, 2020). However, even with various feedback sources available it is still lacking in consistent quantity and quality (Wilson et al., 2022). Along with infrequent provision there are existing barriers in place for paramedics receiving feedback which hinders professional and organisational learning (O'Hara et al., 2015). These include confidentiality issues, loss of further patient contact, experience, and skill level. Providing tailored, individual feedback to improve competency is also a resource-intensive process (Eaton-Williams et al., 2020a; O'Connor & Megargel, 1994).

Understanding what role feedback plays is essential to standardising and improving the quality of patient care provided by paramedics. For example, a recently published systematic review meta-analysis summarised how feedback affects the quality and safety of patient care in an Emergency Medical Services environment (Wilson et al., 2023). Another literature review focused on ambulance clinicians, highlighted how clinical performance is improved with feedback however, the effect on patient outcomes is unclear (Eaton-Williams et al., 2020a). Both reviews examined feedback only within a patient outcome context and highlights the literature gap on the concept of feedback in the paramedicine space compared to other health professions. This scoping review will focus on addressing this gap by encompassing all concepts of feedback. The aim of this scoping review is to determine how feedback is used within paramedicine.

METHODS

Protocol and registration

This scoping review followed the Joanna Briggs Institute (JBI) guide for scoping reviews and adhered to the PRISMA extension for scoping reviews (PRISMA-ScR) (Aromataris & Munn, 2020; Tricco et al., 2018). A scoping review is chosen to map and summarise the existing literature, develop themes, and identify areas for future research (Munn et al., 2018). PRISMA-ScR is recommended in paramedicine scoping reviews as a standardised reporting format (Williams & Beovich, 2020). This scoping review was registered through the Open Science Framework[JF1] (Foster, Todd, & Williams, 2023).

Inclusion criteria

Population

Eligible studies included Paramedics, Emergency Medical Technicians (EMTs), or Emergency Medical Services (EMS). EMTs and EMS were included in the population field to increase the sensitivity of a paramedic filter (Olaussen, Semple, Oteir, Todd, & Williams, 2017).

Concept

Primary studies which included feedback were included. The term "feedback" was not defined in this scoping review to capture all eligible literature.

Context

Any form of feedback provided or received within a domain of paramedicine practice or out-of-hospital environment.

Source of evidence screening and selection

A database search was undertaken including MEDLINE, CINAHL, EMCARE, and SCOPUS. Grey literature was also searched using TROVE and Google Scholar. The literature search was completed from inception to 28th March 2023.

An initial search using MEDLINE was conducted to identify suitable MeSH terms and keywords. MeSH terms were adopted for each database. The following search terms were used; Paramedic*, Emergency Medical Technicians.MeSH, Emergency Medical Services.MeSH, feedback, paramedicine, ambulance*.

Eligible articles were exported into Endnote X20 before importing to COVIDENCE for duplicate removal and screening (The Endnote Team, 2013; Veritas Health Innovation, 2023). Two reviewers (JF and ST)independently screened the title and abstract for eligibility and then full-text review. Any conflicts were resolved by discussion. A third reviewer (BW) was available to resolve any unresolved conflicts however was not required. One author (JF) performed forward and backward citation chaining to identify further eligible studies.

Eligibility criteria

Peer-reviewed literature with any empirical-methodological approach was included. Literature reviews and studies not in English were excluded. There were no date restrictions placed on the literature search.

Data extraction

One reviewer (JF) performed data extraction on full-text articles into a data extraction template (See Table 1).

Legend
ALS = Advanced life support,
CPD = Continuing professional development,
CPR = Cardiopulmonary resuscitation,
ED = Emergency department,
EMS = Emergency medical services,
EMT = Emergency medical technician,
ERC = European resuscitation guidelines,
PLE = Pronounced life extinct,
TCA = Traumatic cardiac arrest

TABLE 1 Legend

Search results

Database searches revealed 423 records (MEDLINE n = 96, CINAHL n = 88, EMCARE n=82, SCOPUS n = 157). A total of 216 duplicates were removed by COVIDENCE. A total of 207 records were screened for title and abstract with 184 records excluded. Eight records were excluded after a full-text review. Six studies were retrieved through hand-searching grey literature (TROVE n = 1, Google Scholar n = 5) with one record excluded. After full text screening a total of 20 records were included in this scoping review. A PRISMA flow diagram summarises results and shows reasons for exclusion (Figure 1).

Article	Location	Study Type	Population	Sample Size	Outcomes	Key findings	Theme
Avery, P., Thompson, C., & Cowburn, P. (2023).	United Kingdom	Mixed Methods	Paramedic training officers	n = 48	Evaluating improvement of Training officer paramedics through providing a simulation-debrief model.	Feedback from higher clinical sources is valued Immediate debriefing post-learning improved confidence Feedback and debriefing allow questions to complete the learning loop Feedback identifies errors and reinforces learning outcomes in an educational environment.	Education
Bleijenberg, E., Koster, R. W., de Vries, H., & Beesems, S. G. (2017).	Netherlands	Quantitative Statistical analysis	Paramedics and ambulance drivers	n = 34 17 paramedics 17 ambulance drivers	Study impact of post-resuscitation feedback on CPR quality	Feedback modifies behaviour during resuscitation Cardiac compression quality improved after receiving specific feedback	Resuscitation
Brinkrolf, P., Lukas, R., Harding, U., Thies, S., Gerss, J., Van Aken, H., Lemke, H., Schniedermeier, U., & Bohn, A. (2018).	Germany	Quantitative Statistical analysis	Paramedics and emergency physicians	n = 205 102 equipped with feedback devices (75 paramedic, 27 physician) 103 unequipped (77 paramedics, 26 physicians)	Assess what is the acceptance level of real-time feedback Differences between crews with or without the equipment What aspects of real-time feedback have different acceptance levels	Ambulance crews have a positive attitude towards real-time resuscitation devices Ambulance crews perceive some aspects of feedback devices to improve safety	Resuscitation
Charlton, K., McClelland, G., Millican, K., Haworth, D., Aitken-Fell, P., & Norton, M. (2021).	United Kingdom	Quantitative Statistical analysis	Paramedics EMT Clinical Care assistants	n = 106 78 paramedics 28 non-paramedic	Primary outcome: Determine ventilation percentage difference in compliance following ERC guidelines with or without feedback Secondary outcome: Explore differences between paramedic and non-paramedic crews	Real-time ventilation feedback modified behaviour and improved ventilation quality Staff are receptive to using feedback devices	Resuscitation
Choi, B., Tsai, D., McGillivray, C. G., Amedee, C., Sarafin, J. A., & Silver, B. (2014).	USA	Quantitative Comparative analysis	Ambulance Clinicians	53/59 ambulance services in the state Did not specify the clinician's skill level	Evaluated whether hospital-directed EMS stroke follow-up tool improved documentation of adherence to EMS stroke protocols	Standardised feedback improved compliance with protocols Feedback modifies clinical behaviours/interventions and improves documentation Interprofessional feedback on specific patient groups improved care standards	Quality Improvement
Eaton-Williams, P., Mold, F., & Magnusson, C. (2020).	United Kingdom	Qualitative Phenomenological study. Semi-structured interviews	Paramedics	n = 8 From a total of 40 staff Convenience sampling from only one ambulance station	Explore paramedic perceptions of clinical performance feedback and attitudes towards the introduction of formal mechanisms for providing patient outcome feedback	Paramedics perceive formal feedback as absent or inadequate Paramedics want feedback on developmental and emotional needs Informal routes are taken when the formal routes are not sufficient Professional and emotional needs left unmet may increase work-related stress leading to a retention issue Negative feedback given should be done with positive intent and in a supportive environment Patient outcome feedback may reduce paramedic clinical isolation in the healthcare service. There are potential positives and negatives to receiving feedback depending on the nature of the feedback Monitored or supported feedback is resource intensive	Personal and Professional development
Hellevuo, H., Sainio, M., Huhtala, H., Olkkola, K. T., Tenhunen, J., & Hoppu, S. (2014).	Finland	Quantitative Statistical analysis	Paramedics	n = 24	Analyse if CPR quality during transportation can be improved with a feedback device Determine compression depth	Real-time feedback devices improves compression depth and rate by modifying behaviours	Resuscitation

TABLE 1: Results

Article	Location	Study Type	Population	Sample Size	Outcomes	Key findings	Theme
Lyngby, R. M., Clark, L., Kjoelbye, J. S., Oelrich, R. M., Silver, A., Christensen, H. C., Barfod, C., Lippert, F., Nikoletou, D., Quinn, T., & Folke, F. (2021).	Denmark	Quantitative Statistical analysis	Paramedics EMT	n = 64 8 ALS paramedics 56 BLS paramedics	Ventilation quality (rate and tidal volume) Simulated environment	Ventilation quality improved with real-time feedback by modifying behaviours	Resuscitation
Lyon, R. M., Clarke, S., Milligan, D., & Clegg, G. R. (2012).	United Kingdom	Quantitative Statistical analysis	Ambulance crew (paramedic and non-paramedics)	n = 137	Assess the quality of prehospital resuscitation pre and post-individual feedback and training based on objective data captured by defibrillator telemetry.	Resuscitation can either be real-time through devices or post-event to evaluate the performance Both forms modify clinician behaviour to improve the quality of resuscitation	Resuscitation
McGuire, S. S., Luke, A., Klassen, A. B., Myers, L. A., Mullan, A. F., & Sztajnkrycer, M. D. (2021).	USA	Quantitative Descriptive statistics. Online survey	EMT Paramedics	n = 94 61 paramedics, 33 EMT's 20% response rate	Describe the frequency of feedback received by ground-based EMS Factors associated with receiving feedback and how follow-up on patient outcomes related to EMS provider job satisfaction	There is a large lack of feedback provision to EMS staff both in quantity and quality Feedback has an impact on job satisfaction Feedback is reinforcing or constructive, a lack of feedback will miss clinical errors and not reinforce positive behaviours Better working relationships with other health providers may lead to better feedback provision systems Paramedics are often the first medical contact but do not get feedback for closure on outcomes Junior staff receive more feedback due to close supervision. Senior staff are often overlooked for feedback. Confidentiality is a barrier to feedback provision	Personal and Professional development
McGuire, S. S., Luke, A., Klassen, A. B., Myers, L. A., Mullan, A. F., & Sztajnkrycer, M. D. (2021).	United Kingdom	Qualitative Semi-structured interviews	Paramedics EMT Clinical supervisors One ambulance service	n = 20 9 paramedics 4 EMT's 3 specialist paramedics 4 clinical supervisors	Explore perceptions of EMS professionals regarding the current provision of feedback and their view on how feedback impacts patient care, safety and staff wellbeing	Feedback provides paramedics validation on clinical decision making Paramedics want feedback for personal and professional development Barriers to feedback provision include time, confidentiality, resources and clinical isolation Feedback essential for paramedic self-reflection and supporting CPD, a fundamental professional competency Feedback should be given on an individual basis in a timely manner based on targets	Personal and Professional development
Mock, E. F., Wrenn, K. D., Wright, S. W., Eustis, T. C., & Slovis, C. M. (1997).	USA	Quantitative Observational study	Paramedic and EMT	n = 69 26 EMT's 43 Paramedics	Determine the type and frequency of immediate, unsolicited feedback received by EMS from patients, families and ED personnel	There is a distinct lack of feedback provided to EMS by family or ED staff A lack of feedback may lead to feelings of lack of recognition Feedback is more likely with critically unwell patients Feedback should be given in a structured way in an emotive atmosphere	Personal and Professional development
Morrison, L., Cassidy, L., Welsford, M., & Chan, T. M. (2017).	Canada	Qualitative Semi-structured interviews Interpretive descriptive technique	Paramedics	n = 12 From a total of 324 paramedics in the region	Explore paramedics perceived needs for feedback Explore what feedback they felt would improve their performance as healthcare providers	Paramedics desire feedback Clinical feedback can be positive or negative Formal feedback or informal feedback There are barriers to feedback There is a lack of frequency and consistency in receiving feedback Feedback is seen as an educational tool There are potential positives and negatives to staff receiving feedback	Personal and Professional development

TABLE 1: Results (continued)

Article	Location	Study Type	Population	Sample Size	Outcomes	Key findings	Theme
O'Connor, R. E., & Megargel, R. E. (1994).	USA	Quantitative Statistical analysis	All paramedics in New Castle County, Delaware	6 ALS units were in operation at the time Each ALS unit consisted of a 2 person team	QI process conveying results on chart audits to identify deficiencies and encourage improvement.	Quality Improvement feedback improves documentation and modifies paramedic behaviour Group feedback is less resource intensive and appropriate when a large percentage of staff are substandard Group feedback doesn't remove the need for individual feedback Individual feedback provided when a small percentage of staff are substandard	Quality Improvement
Ødegaard, S., Kramer-Johansen, J., Bromley, A., Myklebust, H., Nysaether, J., Wik, L., & Steen, P. A. (2007).	Norway and United Kingdom	Quantitative Statistical analysis	ALS-trained ambulance staff	n = 80	Determine if physical capability affects the quality of chest compressions	Real-time feedback improves chest compression quality Visual and audio feedback effective in modifying behaviour	Resuscitation
O'Meara, P., Munro, G., Williams, B., Cooper, S., Bogossian, F., Ross, L., Sparkes, L., Browning, M., & McClounan, M. (2015).	Australia	Quantitative Quasi-Experimental	Final-year Paramedicine and nursing students	n = 39 20 nursing students 19 paramedicine students	Determine if eye tracking and video feedback improves the quality of feedback and enhance situational awareness in students undertaking simulated emergency training	Video feedback is an educational tool to reflect on how to improve future performance	Education
Persse, D. E., Key, C. B., & Baldwin, J. B. (2002).	USA	Quantitative Prospective Chart review	Patients	n = 151	Determine if the quality improvement feedback loop would change the decision-making of paramedics	Objective feedback motivates paramedics to improve patient care Objective feedback prompted self-reflection on practice Feedback modified paramedic behaviour with non-conveyance rates	Quality Improvement
Rebecca E. Cash, Remle P. Crowe, Severo A. Rodriguez & Ashish R. Panchal (2017)	USA	Quantitative Cross-sectional. Electronic questionnaire	EMT grade (43.4%) or higher Paramedics (46.1%) in a civilian setting	n = 15,766 From a total of 310,711 on the register	Describe prevalence of feedback received within 30 days -Areas for feedback -Who gave it -Timing of it -Usefulness Factors associated with receiving feedback within 30 days	Feedback is not routinely given Lack of feedback is a missed opportunity for education and improving patient care Majority of feedback is given verbally and informally. Informal feedback is often given soon after the event by colleagues Formal feedback was given by more senior clinicians days after the event. Feedback has a higher value from senior clinicians Need to optimise the feedback process. Potential for more dedicated time with senior clinicians Junior clinicians and higher skillset paramedics more likely to receive feedback Senior staff may not recognise they are being given feedback Lack of data sharing is a barrier to feedback EMS staff want to be given feedback to improve patient care	Personal and Professional development
Ter Avest, E., McWhirter, E., Dunn, S., Griggs, J. E., & Lyon, R. M. (2019).	United Kingdom	Quantitative Descriptive statistics	Air Ambulance teams (1 doctor and 1 paramedic) Patients who died from traumatic cardiac arrest	n = 159	Percentage of patients with TCA PLE and cause of death established by coroners report Agreement between clinical diagnosis and coroners report for patients who die after TCA	A lack of feedback leads to a missed opportunity to evaluate the care provided and improve pattern recognition Interprofessional feedback and data sharing are not routine and are an opportunity to improve patient care	Quality Improvement
Weber, A., Delport, S., & Delport, A. (2022).	Australia	Quantitative Statistical analysis	Paramedic students	n = 40	Evaluate providing real-time feedback on the provision of CPR quality Evaluate fatigue from maintaining CPR	Real-time feedback improved cardiac compression depth by modifying behaviours	Resuscitation

TABLE 1: Results (continued)

Study characteristics

A total of 16 studies were quantitative, three qualitative, and one mixed-methods in nature. The year of publication ranged from 1994 to 2023 with a median year of 2017. The focus of the studies was paramedics only (n = 6), mixed skillsets (n = 11), students (n = 2), and patients (n = 1). The study focused on patients was included as it involved a feedback loop involving paramedics. Figure 2 displays the distribution of studies based on their country of origin (Figure 2).

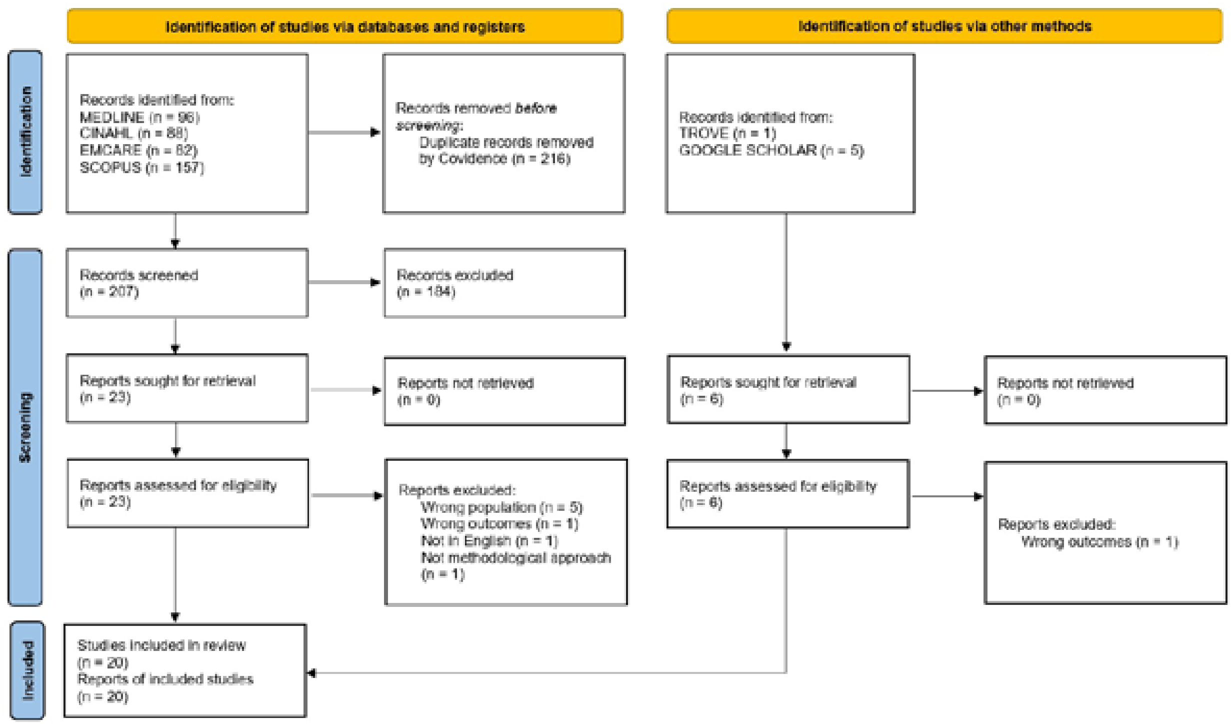

Figure 1. PRISMA flow diagram

After data extraction four overarching themes were developed. These themes were Personal and Professional Development, Quality Improvement, Resuscitation, and Education.

Feedback in personal and professional development

A total of six records were categorised into the theme of personal and professional development. In the UK three qualitative studies highlighted how paramedics desired and described clinical feedback as an essential aspect of personal, emotional, and professional development (Eaton-Williams et al., 2020b; Morrison, Cassidy, Welsford, & Chan, 2017; Wilson et al., 2022). Patient outcome feedback was desired for emotional closure, clinical curiosity, and self-reflection to improve future patient care (Cash et al., 2017; Morrison et al., 2017). Paramedics described that when feedback needs are unmet there is an increase in work stress due to patient outcome or clinical diagnosis uncertainty leading to burnout and a retention issue (Eaton-Williams et al., 2020b).

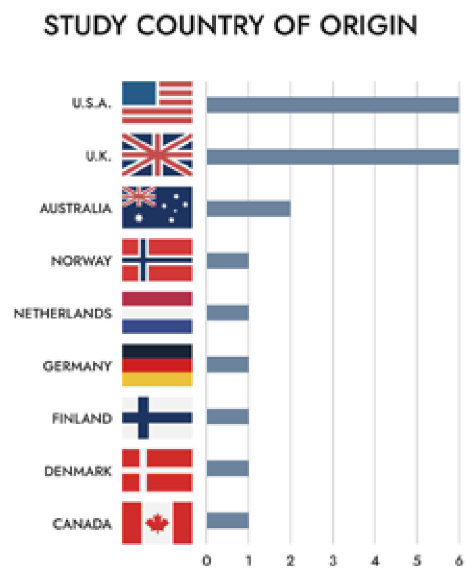

Figure 2. Study country of origin

Multiple studies including qualitative and quantitative methodologies reported a perceived lack of feedback in consistency, quality, and quantity (Cash et al., 2017; Eaton-Williams et al., 2020b; McGuire et al., 2021; Morrison et al., 2017). Two studies from the USA reported that 30% and 50% of staff had received no feedback within the last 30 days (Cash et al., 2017; McGuire et al., 2021). A lack of feedback may lead to feelings of lack of recognition (McGuire et al., 2021; Mock, Wrenn, Wright, Eustis, & Slovis, 1997). Junior staff and staff with higher clinical skillset were more likely to receive feedback compared to senior staff who were often overlooked (Cash et al., 2017; McGuire et al., 2021). One study reported junior staff with less than two years of experience were more likely to receive feedback while staff with greater than 16 years of experience had 41% lower odds (Cash et al., 2017). However, the same study acknowledged senior staff may not recognise feedback is being provided due to their seniority. In the emergency department, ambulance paramedics were not given unsolicited feedback by family members 76% of the time or emergency department staff 73% of the time (Mock et al., 1997).

Feedback provided was classed as formal or informal, with informal routes being provided more frequently (Eaton-Williams et al., 2020b; Morrison et al., 2017). The most common route for informal feedback was verbal (94.8%), followed by email (35.1%), written (18.5%), and by mobile text (16.3%)(Cash et al., 2017). Feedback was most common from a crewmate or partner (70.9%) followed by supervisors (59.6%), hospital staff (57.4%), training officers, (42.6%) and medical directors (20.6%) (Cash et al., 2017). Email was the most common form of formal feedback from a senior officer four days after an event and verbal feedback provided by a crewmate was the most common informal route (Cash et al., 2017). Feedback was deemed to have more value from sources of higher clinical authority (Cash et al., 2017). Existing barriers to feedback provision included time, confidentiality, and clinical isolation (McGuire et al., 2021; Wilson et al., 2022). Monitored and supportive feedback was also reported as a labour-intensive barrier (Eaton-Williams et al., 2020b).

Feedback is also categorised as being reinforcing (positive) or constructive (negative) with benefits and risks to both (McGuire et al., 2021; Morrison et al., 2017). One study from the USA suggested 60% of staff received no constructive feedback and 65% received no reinforcing feedback within 30 days (McGuire et al., 2021). There are perceived risks in receiving reinforcing and constructive clinical feedback and it should be provided in a timely manner based on specific targets (Eaton-Williams et al., 2020b; Mock et al., 1997; Wilson et al., 2022). Reinforcing feedback increased clinician confidence and job satisfaction (Eaton-Williams et al., 2020b; Morrison et al., 2017). Conversely, constructive feedback could damage the clinician's self-image and promote fears of reprimand (Eaton-Williams et al., 2020b; Morrison et al., 2017).

Feedback on quality improvement

A count of four records were categorised under Quality Improvement (QI). Feedback is provided in QI to set standards, evaluate performance, and facilitate improvement (O'Connor & Megargel, 1994; Persse et al., 2002). Specific feedback loops positively modify behaviours in line with expected clinical practice and improve documentation quality (Choi et al., 2014; O'Connor & Megargel, 1994). Group feedback can be used when a large percentage of staff are substandard while individual feedback is provided when a small percentage of staff are substandard (O'Connor & Megargel, 1994). A QI feedback loop improved endotracheal intubation documentation compliance (84.4% -> 98.8%) and decreased trauma scene times greater than 10 minutes (24.8% to 1.4%) (O'Connor & Megargel, 1994). Another feedback loop reduced the number of dissatisfied patients (8 -> 0) and reduced the number of paramedic-initiated non-conveyance in the elderly (14-> 4) although this was not statistically significant (Persse et al., 2002). This feedback loop consisted of a training conference capturing paramedics and facilitators who emphasised the non-judgemental nature of quality improvement programs.

Two records addressed multidisciplinary sources for QI (Choi et al., 2014; Ter Avest, McWhirter, Dunn, Griggs, & Lyon, 2019). Hospital-directed feedback using a 10-point standardised patient outcome feedback form improved clinical documentation and resulted in a statistically significant increase in overall compliance with stroke-specific state protocols (Choi et al., 2014). A UK study showed 32% of injuries in patients with traumatic cardiac arrest pronounced deceased on the scene were identified by the coroner and not identified on the scene (Ter Avest et al., 2019). A lack of routine feedback with the aims of QI is a barrier to evaluating care and a missed opportunity to improve injury pattern recognition (Ter Avest et al., 2019).

Feedback in resuscitation

A total of eight records were categorised under the theme of feedback in resuscitation. Most resuscitation-themed records originated in Europe (n = 7) and one record from Australia. Feedback within resuscitation was given immediately using real-time feedback devices or post-resuscitation to evaluate performance (Lyon, Clarke, Milligan, & Clegg, 2012). Regardless of feedback type there was an improvement in resuscitation quality achieved by modifying clinical behaviours to adhere to existing resuscitation guidelines (Bleijenberg, Koster, de Vries, & Beesems, 2017; Charlton et al., 2021; Hellevuo et al., 2014; Lyngby et al., 2021; Lyon et al., 2012; Odegaard et al., 2007; Weber, Delport, & Delport, 2022). There was also a theme of narrowing the performance range through a reduction in extremes of values (Bleijenberg et al., 2017; Charlton et al., 2021; Lyngby et al., 2021; Lyon et al., 2012). Among paramedics, there was a generally positive attitude towards the use of resuscitation feedback devices (Brinkrolf et al., 2018; Charlton et al., 2021). Feedback was classed into auditory, visual, and voice prompts and there was a perception of increased safety with use (Brinkrolf et al., 2018). In Germany, 87.4% of staff had positive attitudes with satisfaction increasing with repeated training and exposure (Brinkrolf et al., 2018).

A total of two records focused on providing real-time ventilation feedback within a simulated environment (Charlton et al., 2021; Lyngby et al., 2021). A Danish study revealed how ventilation quality was significantly superior to real-time ventilation in a simulated environment (Lyngby et al., 2021). There was an improvement in ventilation rate (66.7% -> 97.4%), volume (53.4% -> 77.5%) and combined rate and volume (22.1 -> 75.3%). This significant improvement in ventilation quality was also seen in a UK study where compliance with European Resuscitation Council guidelines increased (9% -> 91%) (Charlton et al., 2021).

The use of a real-time chest compression feedback device modifies behaviours to improve chest compression quality (Bleijenberg et al., 2017; Hellevuo et al., 2014; Lyon et al., 2012; Odegaard et al., 2007; Weber et al., 2022). Simulated chest compressions in a moving vehicle improved chest compression depth (51mm -> 56mm) with an emphasis on reduced extremes of values (Hellevuo et al., 2014). Real-time visual and auditory feedback can be used to overcome physical and emotional barriers to provide correct compression depth and compression quality and can allow for positive modification with real-time feedback regardless of physical capability (Odegaard et al., 2007). One record found compression quality increased with Australian paramedic students who also reported increased fatigue with increased compression depth (Weber et al., 2022). Two records focused on comparing resuscitation quality pre- and post-feedback for prehospital cardiac arrests (Bleijenberg et al., 2017; Lyon et al., 2012). A study from the Netherlands focused on the impact of providing feedback on compression rate, fraction, and post-shock pause from defibrillator downloads post-cardiac arrest (Bleijenberg et al., 2017). After peer-to-peer feedback was provided, compression fraction increased (79% -> 86%) and the longest post-shock pause decreased (40 seconds to 19 seconds). This was similar in a UK study where providing individual feedback on defibrillator downloads increased compression fraction (73% -> 79%) and a reduction in median time to shock (20.25 seconds to 13.5 seconds) (Lyon et al., 2012).

Feedback in education

A count of two records were placed into the theme of feedback used in education and both shared similar traits where feedback was provided promptly post-event in a controlled educational environment. One record included the use of recorded video feedback on student paramedicine performance in Australia within a simulated educational environment (O'Meara et al., 2015). Students highly valued this form of feedback and its use to guide and reflect on their practice to improve future performance. Another record focused on providing immediate feedback to training officer paramedics after a simulated scenario in the United Kingdom (Avery, Thompson, & Cowburn, 2023). Feedback was provided by higher sources of clinical authority and linked to pre-defined learning objectives. Training officers reported satisfaction with the quality of feedback provided and improved confidence. Despite the articles in an educational setting with the extremes of paramedicine qualification, we did not identify any records looking at feedback to patient-facing qualified paramedics in an educational environment.

DISCUSSION

The purpose of this review was to examine how the concept of feedback is used in paramedicine due to the literature gap and the advantages of feedback observed in other health professions (Ivers et al., 2012). By synthesising the results of this review, this discussion will explore the current practices and challenges and identify future insights. Paramedics have a strong desire to receive feedback to achieve personal and professional closure however these needs are currently not being adequately met. There is a perceived infrequency and inadequacy of received feedback alongside an inequality with experienced staff less likely to receive it. Informal feedback routes are often sought through the form of a work colleague when formal routes such as workplace reviews are inadequate and do not satisfy this strong need for feedback. When feedback has been provided, particularly within resuscitation or quality improvement domains, there are positive modifications in behaviour to improve clinical performance. This suggests paramedics have a positive attitude to improve their own ability to provide quality patient care. Although feedback positively modifies paramedic compliance it is unclear if this directly improves patient outcomes. Within an educational context, promptly provided feedback is highly valued by recipients.

The perceived inconsistency and inadequacy of feedback among paramedics is concerning despite the effects it has on modifying behaviour and improving clinical performance. However, this is not unique to paramedics as residency doctors have also reported poor feedback mechanisms, suggesting this may not be limited to the paramedicine profession (Ramani et al., 2017). Increasing the frequency of reinforcing feedback should satisfy the lack of recognition and may enhance paramedic resilience and self-confidence in a health care profession with numerous stressors (Eaton-Williams et al., 2020a). Informal peer-to-peer feedback among paramedics is the dominant source of feedback, most likely due to the immediate accessibility from a trusted colleague. Therefore, paramedics should be provided with adequate training in feedback provision and there is potential to establish a robust system of peer-to-peer feedback. However, there is a risk of peer-to-peer feedback being positively skewed due to an unwillingness to upset colleagues (Ramani et al., 2017; Stockdill, Hendricks, Barnett, Bakitas, & Harada, 2023). Within the hospital environment peer-to-peer feedback is seen as a potentially underutilised and low-resource method for improving clinical performance (Stockdill et al., 2023). However, paramedics often work in a unique out-of-hospital environment and feedback requirements may therefore be different to that of other health professionals. This distinct working environment should also take into consideration other factors such as workplace culture and existing barriers.

The organisational culture and existing barriers can partly attribute to inconsistent and inadequate feedback provision. An organisation's underlying culture should lay the foundations of effective feedback provision by moving away from a culture of blame and see all forms of feedback, particularly constructive, as an opportunity for learning (Ramani et al., 2017). Being within a supportive and fair organisational culture that is willing to learn from mistakes improves the overall reception of constructive feedback (Plunkett, 2022; Ramani et al., 2017). Additionally, constructive feedback should be delivered with a clear position of positive intent, using a structured approach in a supportive environment to minimise damage to self-perception (Eaton-Williams et al., 2020b; Mock et al., 1997; Ramani et al., 2017). In addition to addressing the underlying culture, it is crucial to address existing barriers hindering effective feedback provision. Patient outcome feedback is challenging due to the loss of patient contact as they are transferred or discharged from care. Inconsistency is also partly attributed to confidentiality and non-integrated health systems. Integrating feedback within a multidisciplinary setting may lead to mutual learning and potentially reduce the clinical isolation often felt by paramedics. There is currently no widely accepted standardised feedback template which may also explain the inconsistency. The use of a standardised template provides this consistency and a concurrent improvement in performance (Choi et al., 2014). Despite these barriers, there are clinical areas, such as resuscitation, when feedback has been successfully implemented into paramedic practice.

The ability of emergency ambulance paramedics to perform resuscitation skills remains a fundamental competency and is imperative to improving cardiac arrest outcomes (Dyson et al., 2016). It is therefore unsurprising to see how most records investigated either real-time or post-incident feedback. Providing resuscitation feedback to paramedics produced an improvement in future clinical performance suggesting paramedics are receptive to feedback. In particular, the use of real-time feedback devices provides a method to immediately and positively modify critical resuscitation skills such as reduced time to shock along with chest compression and ventilation quality. This is reflected in current international resuscitation guidelines recommending that real-time devices are used in clinical practice to ensure quality resuscitation across emergency care systems (Wyckoff et al., 2021). However, the uptake and type of devices used within the emergency ambulance services are unknown. Outside of resuscitation, feedback has also demonstrated its benefits in an educational context, particularly with student paramedics.

Feedback is an established part of health education and is one of the most important interactions between a student and a teacher (Burgess et al., 2020). Student paramedics are often in a position where feedback is constantly provided under close supervision through their mentors or educators. A scoping review on paramedic student clinical education placements revealed that student paramedics demonstrate high levels of self-motivation and place clear requirements on the need for clear, objective feedback (Carroll, Peddle, & Malik, 2023). This feedback is seen as crucial for enhancing their foundational knowledge and facilitating a better understanding of their own progress. Implementing regular feedback throughout the paramedic s career can serve as a method to maintain and nurture this early motivation and curiosity. However, our findings suggest there is a decline in feedback given to clinicians after two years of experience, despite the importance of a paramedic’s ongoing development. This highlights a feedback inequality and feedback should be provided on a continuum throughout the paramedic s career and not decline after reaching qualified status. Additionally, we only identified two records under the theme of education and the scarcity of literature on feedback within paramedic education might suggest a need to evaluate feedback provision in this setting.

Areas for further research

All articles investigated the reception of feedback and further research should explore the prevalence and content of feedback that is provided by paramedics. A standardised feedback template using paramedic or multidisciplinary insight should reduce feedback inequalities and represents a future area of interest. There is an opportunity to explore multidisciplinary collaboration using feedback to reduce institutional barriers. Although feedback in QI improved clinician performance further research should establish if there is a link between feedback and patient outcomes.

Strengths and limitations

As far as we know this is the first scoping review to look at how feedback is used in paramedicine and the review followed a structured PRISMA-ScR framework (Tricco et al., 2018). Paramedic-specific search terms were used to increase sensitivity (Olaussen et al., 2017). Despite this, several limitations should be considered. The literature is not solely focused on paramedics and includes other emergency medical staff due to different EMS models around the world. Consequently, this review may not be representative of the paramedicine profession. One reviewer performed the grey literature search, forwards and backward citation tracking, and hand searching. As a result, it is possible some records were not identified for review. One reviewer performed data extraction and there is a risk of bias in the data content extracted and theme development.

CONCLUSION

Feedback is used within paramedicine as part of professional and personal development, quality improvement, resuscitation, and education. Paramedics' desire for formal feedback currently outweighs the infrequent and inconsistent provision, creating a wellbeing concern. There are existing barriers to paramedics receiving feedback that are unique due to their working environment. Feedback modifies behaviour immediately or post-incident and generally improves clinical performance. Feedback is essential in paramedic clinical education and should be continually provided throughout the paramedic's career to facilitate personal and professional growth.

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REVIEW

PREHOSPITAL STANDARDS FOR POINT-OF-CARE ULTRASOUND: A BRIEF NATIONAL REVIEW

Dilpreet Bajwa, BHSc[1]; Jared Price, BSc[1]; Savanna Boutin, MD, BHSc[2]; Ankit Kapur, MB, BSc, BAO, BCh*[1]

Author Affiliations: 1. University of Saskatchewan College of Medicine, Regina, SK, Canada; 2. University of Saskatchewan College of Medicine, Saskatoon, SK, Canada.

**Corresponding Author*: ankit@kapur.org

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ABSTRACT

Background: Point-of-care ultrasound (POCUS) has become an increasingly recognized tool for the rapid bedside assessment of undifferentiated patients. With the advent of affordable portable devices, this tool has expanded to the prehospital world, offering an opportunity to improve patient care prior to arrival in the emergency department.

Methods: To assess how this tool has become incorporated into paramedical care in Canada, we conducted a cross-sectional survey of paramedical regulating bodies across nine of Canada's ten provinces to investigate POCUS accreditation, licensing, scope of practice, and quality assurance regulation for paramedics in Canada.

Results: Overall, few provincial paramedical licensing bodies include POCUS in the scope of practice for prehospital practitioners, and those who do are not involved with POCUS training, licensing, or quality assurance.

Conclusions: Our findings highlight the need for defined national competence standards and quality assurance metrics to ensure safe and effective use of POCUS in the prehospital environment.

INTRODUCTION

Prehospital medical care providers are tasked with the initial assessment and treatment of an extremely broad array of undifferentiated patient presentations, often in austere environments with limited diagnostic tools. In the hospital, point-of-care ultrasound (POCUS) has become an increasingly popular bedside tool for the assessment of similarly undifferentiated patients by emergency physicians, allowing for early and accurate diagnosis of life-threatening diagnoses such as ectopic pregnancy, abdominal aortic aneurysm, and cardiogenic shock (Lewis et al., 2019). Recent technological advances have allowed for the expansion of handheld POCUS to the prehospital environment, offering an innovative way for prehospital practitioners to improve their diagnostic accuracy (Hermann et al., 2022; Smallwood & Dachsel, 2018). Moreover, several studies have identified the feasibility of POCUS by non-physicians (Amaral et al., 2020; Becker et al., 2018; Bøtker et al., 2018; Laursen et al., 2016; Nadim et al., 2021; Pietersen et al., 2021), with non-physician practitioners identifying conditions such as cardiogenic pulmonary edema and abdominal aortic aneurysm with high sensitivity and specificity (Laursen et al., 2016; Schoeneck et al., 2021). Furthermore, prehospital POCUS is used in Europe, Australia, and New Zealand and has been shown to change patient management when used in the setting of trauma, shortness of breath, and cardiac arrest (Bøtker et al., 2018).

However, the establishment of clearly defined standards of competence for prehospital practitioners appears to be lagging behind the needs of our healthcare system. The most recent Canadian national competency profile upon which many prehospital provincial standards are based was published over ten years ago, with no mention of POCUS (Canadian Organization of Paramedics, 2021; Paramedic Association of Canada, 2011). Additionally, the Canadian Association of Radiologists has identified several concerns regarding the expansion of POCUS from formal sonographers with radiologist-interpreted scans to the hands of bedside practitioners (Chawla et al., 2019). They argue that diagnostic US is implicitly dependent on operator training and experience, meaning all practitioners who include POCUS in their scope of practice should be subject to rigorous regulatory standards and quality assurance (Chawla et al., 2019).

In Canada, the main POCUS accrediting body is the Canadian Point of Care Ultrasound Society (CPoCUS), which provides practitioners with a title of "Independent Practitioner" once specific competencies have been demonstrated. Independent Practitioners are able to reliably generate and interpret images to guide patient management. There are also several accredited CPoCUS courses such as Emergency Department Echo (EDE) Courses 1 and 2, Echo Guided Life Support (EGLS), and Emergency and Critical Care Ultrasound (ECCU) offered to medical practitioners. To our knowledge, there has been no assessment of POCUS use, accreditation, or quality standards in the prehospital environment in Canada. This study sought to fill this gap in understanding using a cross-sectional survey-based design, serving as a first step to establishing a safe, clearly-defined role for POCUS use in the prehospital environment.

METHODS

We used a cross-sectional, interview-based survey to collect qualitative data on the current POCUS accreditation and quality assurance practices for paramedics in 9 Canadian provinces. Provincial paramedic governing bodies were contacted by telephone and email. Data was collected between May 2022 and July 2022. A short, structured interview, based on the framework outlined in Table 1, was performed over the phone, and the data was recorded and compiled using Microsoft Excel. Inter-

	Question
1	Do you recognize privileging/licensing for point-of-care ultrasound?
2	If yes, what is the criteria for point of care ultrasound privileges/licensing for paramedics?
3	How do practitioners maintain ongoing privileges/licensing, and how is quality assurance/improvement implemented?
4	What scope of practice is acceptable for practitioners with point-of-care ultrasound privileges/licensing (i.e. what specific scans can be practiced)?

Table 1. Qualitative interview framework questions assessing POCUS accreditation and quality assurance standards for prehospital practitioners across Canada.

views were held with at least one representative from the governing body from each province. Overall, information was gathered based on the interview framework from 9 provinces. Quebec was excluded due to language barriers, and the three Canadian territories were excluded as they are currently not formally regulated independently or by territorial governments; the territorial prehospital setting is predominantly managed by individual paramedic employers. All data collected is presented in this paper. Funding was provided from the University of Saskatchewan College of Medicine, Regina Campus, in the form of a $5000 undergraduate and resident research support grant.

ETHICS

This project was exempt from ethics review from the Research Ethics Board of the University of Saskatchewan under article 2.5 of the Tri-Council Policy Statement (2018).

RESULTS

Our findings indicate that POCUS is recognized as being within the scope of practice only for advanced care paramedics (ACPs) and critical care paramedics (CCPs) in Manitoba, Saskatchewan, and Alberta (Table 2). Most representatives from the paramedical governing bodies in Canada identified the process of POCUS training, quality assurance, and accreditation as being the responsibility of paramedic employers in the province (Table 2).

Province	Regulating body	Presence of POCUS accreditation processes	Quality assurance and ongoing POCUS privileging	Scope of practice
Alberta	Alberta College of Paramedics	None	None	Not specified
British Columbia	Emergency Medical Assistants Licensing Board	None	None	Not specified
Manitoba	College of Paramedics Manitoba	Specific to employer, for ACPs and CCPs only	Additional training and quality assurance maintained by the employer	Within scope for ACPs and CCPs
New Brunswick	Paramedic Association of New Brunswick	None	None	Out of scope
Newfoundland and Labrador	Newfoundland and Labrador Paramedicine Regulator	None	None	None
Nova Scotia	College of Paramedics of Nova Scotia	College would verify additional employer-provided training is adequate to Accreditation Canada Standard	Accreditation Canada Standards	Employer specific
Ontario	Ontario Ministry of Health	None	None	None
Prince Edward Island (PEI)	Emergency Medical Services Board of PEI	None	None	None
Saskatchewan	Saskatchewan College of Paramedics	CCPs only, employer-specific	Set provincially, individual employer is responsible for annual evaluation and quality improvement	Focused Assessment with Sonography for Trauma (FAST) scans

Table 2. Summary of POCUS accreditation, quality assurance, and scope of practice standards for paramedics in Canadian provinces. ACP: advanced care paramedic; CCP: critical care paramedic.

DISCUSSION

Our data suggest that although point-of-care ultrasound (POCUS) may be expanding to the prehospital domain in Canada, the regulation, accreditation, and quality assurance infrastructure for the use of this tool in paramedicine is in its infancy in Canada. Most paramedical regulatory bodies and representative associations in Canada are not involved in regulating POCUS use by paramedics (Table 2). Additionally, POCUS is recognized as being within the scope of practice only for specially trained paramedics in Saskatchewan, Alberta, Manitoba, and British Columbia, and its training, quality assurance, and privileging is left to individual employers (Table 2). The structure of prehospital care in Canada provides a unique challenge to standardized regulation, as there is variation in the scopes of practice across classes of paramedic qualifications between and within provinces, and many provinces have a mix of public and private prehospital care providers. Within this structure, individual employers can dictate additional skills that are within the scope of practice of paramedics of various levels. For example, POCUS is used in prehospital care during air transport in Saskatchewan and Ontario, but only in the hands of advanced care flight paramedics who have additional training provided by their air medical transport employers.

Despite our results showing minimal standardization of POCUS training, accreditation, and quality assurance for prehospital practitioners in Canada, many provincial regulating bodies expressed interest in including POCUS training in the paramedic curriculum. In a recent survey similar to ours, providers in the UK identified lack of prehospital POCUS governance as a major barrier to the use of this tool, despite perceiving it as beneficial for patient care (Naeem et al., 2022); these findings suggest a standardized accreditation process could assist with rolling out of POCUS in the prehospital environment. Furthermore, given that current literature provides conflicting data on the efficacy of POCUS in the hands of paramedics specifically (Becker et al., 2018; Donovan et al., 2022; Nadim et al., 2021; Pietersen et al., 2021; Schoeneck et al., 2021), the current lack of standardization for prehospital POCUS represents a potential opportunity for improved patient care. Additionally, the actual use of POCUS by trained providers has been shown to increase as time spent training increases, underscoring the importance of supervised scanning to allow practitioners to become comfortable using this tool (Leschyna et al., 2019). Concerns regarding the accuracy of POCUS interpretation by prehospital providers could be mitigated by real-time interpretation of prehospital practitioner-generated images by a radiologist or other trained provider (Hermann et al., 2022).

Another challenge facing the expansion of POCUS to prehospital care in Canada and elsewhere in the world is a lack of literature on the subject (Naeem et al., 2022). While prehospital POCUS is known to change patient management in select circumstances, it's effect on patient outcomes remains largely unknown, presenting an exciting area of future research (Amaral et al., 2020; Bøtker et al., 2018).

CONCLUSIONS

Overall, the findings outlined in our study demonstrate the need to develop a nation-wide set of competencies and quality assurance measures for prehospital POCUS use. This study is merely the first step in determining how POCUS can be safely and effectively integrated into prehospital care in Canada; additional studies will be required to determine which scans are of greatest utility, how and if POCUS training for paramedical practitioners changes patient management and outcomes, and how quality assurance can be maintained across the country.

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REVIEW

PARAMEDIC WORKFORCE DISPARITIES MARKED BY GEOGRAPHICAL POSITIONING: COMPARISON OF RURAL AND URBAN REGIONS

Chloe Betts, Bch MSc*[1], Alannah Stoneley, Bch (Hons)[1], Judith Anderson, BN, MN, PhD[1], Clare Sutton, BSc, MSc, PhD Candidate[1]

Author Affiliations: 1. School of Nursing, Paramedicine and Healthcare Sciences, Charles Sturt University, Bathurst, NSW, Australia.

**Corresponding Author*: cbetts@csu.edu.au

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ABSTRACT

Introduction: Effective service delivery and the wellbeing of the paramedic workforce is reliant on confounding factors and is effectuated by geographical positioning. It is important to be aware that there may be several disparities between the rural and urban workforce due to differences in circumstances. However, there is limited literature available examining these. The objective of this review was to investigate where and how these disparities exist to make recommendations in achieving equity in the paramedic workforce and thus achieve patient-centred care universally across rural and urban populations.

Methods: The JBI approach was used to perform a scoping review to assess the availability of literature. Key words including paramedic*, EMT, urban OR metro*, rural OR remote and disparit* were inserted into the search engines MEDLINE, CINAHL Plus and Scopus. Titles and abstracts of the 282 results were screened by two authors and inclusion and exclusion criteria applied. The full text of the remaining 77 results were screened to inform the results of the review.

Results: The search identified 282 potentially relevant articles, of which 33 informed the results of the review. The included studies identified emerging themes relevant to the objective, including: (1) the skills, training availability, and confidence of the workforce; (2) resourcing of ambulances inclusive of both workload and caseload and access to resources; (3) timings of each group regarding response, scene, and transport; and (4) the health status of paramedics in each subset location.

Conclusion: This review identified several disparities between rural and urban paramedic locations to the point that it is negatively impacting equitable patient-centred care. Further research is recommended to establish why these disparities exist and the extent to which these disparities are impacting the ability to achieve equity in the paramedic workforce across these two geographical divides.

INTRODUCTION

The paramedic discipline has a responsibility to the community to provide front-line emergency and low acuity out-of-hospital care. Paramedics are continually faced with evolving caseload and workload which is deemed taxing emotionally, mentally, and physically (Sofianopoulos, Williams, & Archer, 2012). Their treatment and transport of critical patients highlights significant skill deployment where errors in judgement or lapses of concentration may result in fatal consequences. Therefore, their ability to undertake such duties effectively is dependent on several confounding factors (Meadley et al., 2020).

In many countries significant percentages of the population reside in rural or remote areas. For example, in Australia approximately 7 million people reside in rural and remote areas, accounting for 29% of the population. This denotes one in ten living in a small town with a population of less than 10,000 people. Conversely, 71% of the population reside in a metropolitan or urban setting which reflects a population of 100,000 or more residents (Australian Institute of Health and Welfare, 2018). With a variety of ambulance organisations servicing such diverse populations it is important to be aware that there may be disparities between the rural and urban workforce due to differences in circumstances. To effectively identify the cause of paramedic workforce issues, the comparison of geographical positioning must be explored. It is hypothesised that the rural workforce is subject to different organisational and psychosocial stressors arising from servicing diverse patient demographics with poorer access to services. Thus, it would be inappropriate to utilise unified support strategies to both the urban and regional cohort. However, there is limited literature discussing the disparities which exist in the paramedic workforce between these differing locations. The objective of this scoping review was to investigate where and how these disparities exist to make recommendations in achieving equity in the paramedic workforce and thus achieving optimal patient-centred care universally available across rural and urban populations.

METHODS

Methodological Framework and Reporting

This scoping review adheres to the JBI methodology and the preferred reporting items for systematic reviews and meta-analyses extension for scoping reviews (PRISMA-ScR). The search was registered through the OSF register DOI 10.17605/OSF.IO/D3EPF.

Inclusion Criteria

For evidence to be included within the scoping review, articles must have met a pre-determined set of inclusion and exclusion criteria outlined in Table 1. These were developed in line with the PCC (population, concept, context) which were discussed and unanimously agreed upon by all authors.

Search Strategy

The search strategy aimed to locate only published studies. A three-step strategy was utilised for the review. An initial limited search of MEDLINE ALL and CINAHL (EBSCOhost) was undertaken to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles, and the index items used to describe the articles were used to develop a full search strategy for MEDLINE ALL, CINAHL (EBSCOhost) and Scopus (see appendix 1). These databases were selected as they are archives

Criteria for Inclusion	Criteria for Exclusion
Population - Relating to the paramedic workforce explicitly	Nature of the research aimed at the hospital or tertiary perspective
Context - Comparison of the metropolitan or urban paramedic and regional, rural, or remote paramedic	Relating to out-of-hospital healthcare provided by nurses, GPs, or other healthcare professionals whose primary location of work is in hospital
Context - Comparable health care systems	Studies older than 10 years
Concept - Pertaining to the differences in scope of practice and times in both subset locations	Patient outcome focused pertaining to morbidity and mortality
Concept - Identifying incidence and prevalence of disease within the paramedic cohort from differing geography	Concerning the role of treatments or assessments for specific interactions
Concept - Pertaining to the identification of organisational or patient stressors across both subset locations	Grey literature
English language	Not original research, i.e.., literature review, systematic review, meta-analysis

Table 1. Inclusion and exclusion criteria.

for allied health professional, nursing, and pre-hospital or paramedicine literature. This was important as the extent of the existing literature on the topic was unknown.

Key search terms were identified in current research and used as specific search terms including: paramedic*, ambulance, EMT, emergency medical technician*, prehospital, pre-hospital, and out-of-hospital. Other key terms included: urban, metro*, rural, remote, regional, comparison*, imbalance*, disparit*, differ*, dissimilar*, contrast* and variation*. Search terms were combined with appropriate Boolean terms and truncation symbols. The search strategy, including all identified key words and index terms, was adapted for each database and/or information source.

Evidence Screening and Selection

Following the search, all identified citations were collated and uploaded into EndNote and duplicates removed. The initial search of MEDLINE, CINAHL (EBSCOhost) and Scopus resulted in 489 results following the application of limits by date restricting data to within the last ten years (2013-2023). Following the removal of duplicates, 282 articles were left for screening. Following a pilot test, titles and abstracts were screened by two independent reviewers for assessment against the inclusion criteria for the review. Potentially relevant sources were retrieved in full, of which there were 77 articles, and their citation details were imported into the JBI System for the Unified Management, Assessment and Review of Information (JBI SUMARI). The full text of selected citations was assessed in detail against the inclusion criteria by two independent reviewers. Reasons for exclusion of sources of evidence at full text that did not meet the inclusion criteria were recorded and reported in JBI SUMARI. Any conflicts that arose between reviewers at each stage of the selection process were resolved through discussion or with an additional reviewer/s. Of the 77 texts screened in full, 33 were included in the scoping review. The results of the search and study inclusion process were reported in full and are presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for Scoping Reviews (PRISMA-ScR) flow diagram (see appendix 2).

Data Extraction

Data was extracted from papers included in the scoping review by two independent reviewers using a data extraction tool developed by the reviewers (see table 2). The data extracted included specific details about the participants, concept, context, study methods, and key findings relevant to the review objective. Any disagreements that arose between reviewers were resolved through discussion with an additional reviewer.

Data Analysis and Presentation of Results

The data was analysed and charted in line with Arksey and O'Malley's fourth stage of performing a scoping review. This is referred to as a process that extracts and summarises the data in a descriptive and logical way from which further narrative can be written. Six criteria were used to analyse and present the results of each study which included: author(s) and year of publication, location, aim, participants, methods, and key findings. Table 2. Summary of Articles Included, provides an overview of the 33 articles included in this scoping review.

RESULTS

The above search strategy identified 282 potentially relevant articles, of which 33 informed the results of the scoping review. The included studies identified four emergent themes relevant to the objective. The key themes identified in the literature include the disparities that exist between the skills and confidence of the rural and urban workforce followed by the notable differences which could be seen between the caseload, workload, and access to resources between these areas. Additionally, there was also a significant difference in the response and transport times between rural and urban locations accompanied by a disparity in the health status of rural and urban paramedics.

Skills and Confidence of the Workforce

The main theme emerging from the literature was the disparity in skills and confidence of rural paramedics compared to their urban counterparts. Disparities emerged between the rural and urban workforce in four areas: training and education, scope of practice, skill acquisition and maintenance, and confidence. The disparities in training and education between rural paramedics and their urban counterparts impacted on their ability to provide high-quality patient care and impacted on their career development. Paramedics working in rural areas had less training (initial and ongoing) and were often working to a lower scope of practice as extended care and specialist roles were more frequently metro-based. Due to the lower call volume in rural areas, paramedics had less frequent exposure to certain types of calls, increasing the risk of skill erosion, and many reported feeling less confident in utilising their skills than their urban colleagues.

Several studies noted the lack of training for paramedics in rural locations impacted on their opportunities to undertake more advanced or specialised roles resulting in disparities in the scope of practice between rural and urban paramedics (A. Alanazy, Fraser, & Wark, 2021; Alanazy Ahmed Ramdan, Fraser, & Wark, 2021; Irvine, Doan, Bosley, Colbeck, & Bowles, 2022). Paramedics in Saudi Arabia reported opportunities for enhanced education and training were not available to those based in rural locations and staff were expected to travel to urban locations to undergo additional training (A. Alanazy et al., 2021; Alanazy Ahmed Ramdan et al., 2021). Furthermore, staff were expected to relocate to urban areas on completion of their additional training as roles incorporating the extended scopes of practice were only utilised in urban locations (A. Alanazy et al., 2021; Alanazy Ahmed Ramdan et al., 2021). This impacted the level of care that could be delivered to patients in rural locations which was further compounded by a reliance on volunteers to supplement the workforce shortages.

This correlation between frequency of exposure and confidence was reported across a range of presentations, including trauma triage, management of patients having acute myocardial infarctions, out of hospital cardiac arrest management, stroke recognition, and management of mental health patients (Coleman, Barry, Tobin, Conroy, & Bury, 2019; Deeb et al., 2020; Emond et al., 2021; Hodell et al., 2016; Martin Lorelle et al., 2020; Ro et al., 2013). One US study reported under triage of trauma patients was higher among patients in rural areas (8.6% versus 3.4% in urban areas). This was attributed to the infrequent exposure of rural paramedics to trauma cases and the lack of continuing professional development in trauma care (Deeb et al., 2020). Rural paramedics in one US study reported challenges with stroke recognition due to infrequent exposure which was in contrast to their urban colleagues who reported difficulties with stroke recognition arising from language barriers due to the diverse population in the large urban cities (Emond et al., 2021). Paramedics in rural Australia reported lack of confidence with managing complex cardiac patients due to infrequent exposure and lack of training (Martin Lorelle et al., 2020). The notable exception with regards to frequency and confidence was in relation to paediatric airway management where Irish paramedics reported confidence in undertaking the skill with 70% of paramedics having been exposed to this in practice, yet only 23% had received any formal training to prepare them for paediatric airway management (Coleman et al., 2019).

Lack of exposure was problematic in most rural locations as was managing the disparity between the characteristic caseloads for rural which saw more trauma than urban who dealt with more medical calls. Several strategies to counter the impact of infrequent exposure were discussed with one Australian study noting that it would be beneficial for rural paramedics to have professional development sessions in managing mental health patients delivered by specialised mental health professionals (Emond et al., 2021). While potentially beneficial, the study highlighted the challenge of this approach due to the lack of specialised mental health professionals working in rural areas. Feedback from paramedics in an Irish study was that 85% of them would welcome refresher training in paediatric airway management to be conducted by specialists in the hospital environment; however, most acknowledged the logistical challenges as this would require them to travel to urban areas to complete the training (Coleman et al., 2019). Conversely, one US study reported that paramedics in rural areas found it easier to obtain feedback on stroke recognition from other healthcare professionals than their urban colleagues due to the strong interprofessional relationships they had developed with staff at the local hospital (Hodell et al., 2016). This feedback was an important learning tool to develop their confidence in managing strokes due to the infrequent exposure to this type of case.

One Australian study noted a disparity between the outcomes of paediatric out-of-hospital cardiac arrest (OHCA) patients measured through return of spontaneous circulation (ROSC) with urban ROSC rates of 32.5% compared to 20.7% for rural patients despite similar response times (Irvine et al., 2022). A further disparity noted was the paramedic scope of practice with Critical Care Paramedics (CCPs) being present at 92% of the urban OHCA calls and only 63% of the rural OHCA calls. This is noted as one potential contributory factor as the presence of CCPs at OHCA calls has been shown to improve outcomes, however other potential contributory factors include the time taken for paramedics to be called, as patients may not be immediately discovered in rural settings, and the aetiology which was linked to survival rates was found to vary between urban and rural patients (Irvine et al., 2022). Paramedics in the Saudi Arabian study suggested training should be tailored to be more representative of the types of cases typically encountered in their local area (A. Alanazy et al., 2021). It was argued that this would promote confidence in managing trauma cases and potentially reduce skill erosion. This targeted education strategy was also suggested in the Australian study by Irvine et al. (2022) in response to the varied aetiology of paediatric OHCA between rural and urban areas.

There was widespread consensus concerning the disparities between training and education, scope of practice, skill acquisition and maintenance, and confidence of rural compared to urban paramedics. The suggested solutions varied, and while many reported challenges associated with working in rural areas, others identified benefits of working in a more rural setting as part of a more collegial professional community.

Resourcing (Caseload, Workload, Access to Resources)

Caseload

Another theme which emerged from the literature illustrating a disparity between the rural and urban paramedic workforce was the workload and consequent caseload between the two geographical locations and associated resourcing to these areas. When considering caseload, a study conducted by Sariyer, Ataman, SofuoÄlu, and SofuoÄlu (2017), concluded there were less emergency service calls placed in rural regions than urban areas. However, when comparing per 1000 residents, it was found that there was a higher proportion of calls coming from rural regions. This is further complimented by another study conducted in Taiwan whose rural areas had a greater demand per capita than urban regions (Wong Ho, Lin, & Lin, 2019). In addition, rural areas were also seen to service larger geographical locations when compared to urban areas (Lu & Davidson, 2017). This is also shown in an Australian study that identified a consequence of working in an area with rural geography is greater demand on the emergency healthcare system during hot and cold waves (Jegasothy, McGuire, Nairn, Fawcett, & Scalley, 2017). Furthermore, Hegenberg, Trentzsch, Gross, and Pruckner (2019) found that emergencies were more prevalent in urban areas during the day and suggested this was largely due to inbound commuters. They also shared that the number of cases with a prehospital emergency trained physician dispatched was 1.5 times higher in the urban environment than rural locations (Hegenberg et al., 2019). Lastly, A. R. M. Alanazy, Fraser, and Wark (2022) in a Saudi Arabian study investigating differences in non-transports between rural and urban hospitals found that all patients who were treated in the urban environment were transported to hospital. This was not the case in the rural cohort where a small percentage of patients were treated at the scene and not transported to hospital (A. R. M. Alanazy et al., 2022).

Workload

When looking at workload, the literature proposed this was generally more medically dominated in urban areas and more trauma dominated including traumatic out-of-hospital cardiac arrests in rural areas (Alanazy Ahmed Ramdan et al., 2021; A. R. M. Alanazy, Wark, Fraser, & Nagle, 2020; Irvine et al., 2022; Moafa Hassan, van Kuijk Sander Martijn, Alqahtani Dhafer, Moukhyer Mohammed, & Haak Harm, 2020). It was also suggested by Moafa Hassan et al. (2020) that more male patients were seen in rural areas whilst more female patients were seen in urban areas. To further break this down, A. R. M. Alanazy et al. (2020) shows that during trauma cases, rural patients' injury patterns were associated more with fractures, lacerations and head injuries while urban patients more frequently presented with wounds and burns. Overall, the on-scene death rates compared by A. R. M. Alanazy et al. (2020) were low for both rural and urban areas however were more prevalent in the rural locations. When looking into patient-specific treatment, rural paramedics in Poland were seen to treat more on scene and had a higher utilisation of C-spine collars when compared to urban areas where they were seen to gain intravenous (IV) access more frequently than their rural counterparts (Aftyka, Rybojad, & Rudnicka-Drozak, 2014). Cui Eric et al. (2021), found that electrocardiograms (ECGs) of an ischaemic nature were more common in rural areas than urban indicating more ST elevation myocardial infarctions and morphine administration which was two times more common in rural than urban areas. This demonstrates there is a difference in workload and caseload between the rural and urban environment. Whilst there are no direct disparities identified so far in the literature, it is important to also investigate the effect that access to resources has on these factors.

Access to Resources

When taking into account the access to resources that paramedics need to be operational compared to urban areas, rural locations have an increased frequency to require 4x4 vehicles as well as Global Positioning System (GPS) in order to reach their patients (Alanazy Ahmed Ramdan et al., 2021). Alanazy Ahmed Ramdan et al. (2021) highlighted this need as well as the trend that limited resources were available to facilitate this. This is further alluded to in Alanazy Ahmed Ramdan, Wark, Fraser, and Nagle (2019) sharing that there are less ambulance stations in rural areas, along with less staff and reduced equipment that may not be suited to the rural environment. The issue of lack of resources in rural environments is again highlighted by Bush, Glickman Lawrence, Fernandez Antonio, Garvey, and Glickman Seth (2013) whose findings suggest that ECGs were being performed less in rural than urban areas, stating that the largest barrier preventing rural clinicians from performing an ECG was a lack of availability of equipment and certification in these areas resulting in a strong recommendation for increased training and resources in rural areas to correct this disparity. Lastly, another significant disparity in the literature is presented by Alanazy Ahmed Ramdan et al. (2021) highlighting there was insufficient access to trauma facilities and retrieval resources when compared to urban areas. This has also been recognised by Yeap, Morrison, Apodaca, Egan, and Jansen (2014) who recommended regionalisation of trauma care and retrieval capacity to improve these disparities for the paramedic workforce.

Timing

A significant and obvious difference between urban and rural populations is distance between health services. This has significant impacts on paramedic work which is reflected in driving time and its related impact. Due to variations in where studies were undertaken, it was not possible to combine results, with many different definitions of urban, rural, times, and paramedic workforces. However, it was clear that prehospital time was extended in rural areas overall (Ashburn Nicklaus et al., 2022; Clark David, Winchell Robert, & Betensky Rebecca, 2013; Lu & Davidson, 2017; Newgard Craig et al., 2017; Ro et al., 2013; Stopyra et al., 2022; Yeap et al., 2014). One study, based in Japan, contradicted this with fairly similar results for the two areas and a slightly longer prehospital time in urban areas (Masuda et al., 2018).

Response time was also extended in rural areas (Aftyka et al., 2014; A. Alanazy et al., 2021; Ashburn Nicklaus et al., 2022; Connolly et al., 2022; Cui Eric et al., 2021; Hsu, Wu, Huang, Lee, & Cheng, 2021; Lu & Davidson, 2017; Newgard Craig et al., 2017; Ro et al., 2013; Stopyra et al., 2022). Masuda et al. (2018), once again contradicted this with largely similar results with a slightly longer response time in the urban setting (Masuda et al., 2018). A study based in Saudi Arabia (Alanazy Ahmed Ramdan et al., 2021) also indicated that older vehicles were more likely in rural areas, which may increase travel times and specifically response times when they were not equipped with GPS. However, time at the scene was similar between urban and rural areas (Ashburn Nicklaus et al., 2022; Ashburn et al., 2020; Newgard Craig et al., 2017). Stopyra et al. (2022) identified a significantly longer on scene time for rural patients (16.6 mins) than urban patients (15.4 mins). Masuda et al. (2018) once again contradicted this with a longer time at the scene in urban areas (Masuda et al., 2018).

Time to transport patients to hospital was also extended in rural regions (Alanazy Ahmed Ramdan et al., 2021; Ashburn Nicklaus et al., 2022; Cui Eric et al., 2021; Lu & Davidson, 2017; Newgard Craig et al., 2017; Stopyra et al., 2022). In their Japanese study, Masuda et al. (2018) identified that part of the delay in transport to hospital was related to the services provided at the initial hospital in rural locations as being insufficient Ð their study was related to time taken to primary percutaneous coronary intervention (PPCI) in management of acute myocardial infarction. Dual dispatch of emergency medical services and firefighters was also shown to reduce response time in rural Sweden and showed an increase in 30 day survival rates in urban populations; however, limited impact was seen in rural locations (Nordberg et al., 2015). In a study of ECG utilisation, Bush et al. (2013) found that ECGs were more likely to be undertaken in patients with longer transport times and suggested that this was possibly due to the length of time available to do so (Bush et al., 2013).

Paramedic Health Status

The literature has identified that there is a consequential disparity that exists in the health status of paramedics between the rural and urban workforce. Studies have identified that rural paramedics have significantly higher rates of fatigue, depression, anxiety, and stress than their urban counterparts. This is in addition to poorer sleep quality and less reported physical activity (Courtney, Francis, & Paxton, 2013). While there is an increased incidence and prevalence of disease in rural paramedics, it is also evident that rural paramedics have higher metabolic risk profiles and cardiovascular health metrics (Cash, Crowe, Bower, Foraker, & Panchal, 2019). Urbanicity was identified as a key risk factor for reporting suboptimal cardiovascular health. The findings were statistically significant as 57% of the urban cohort had optimal cardiovascular health while the rural workforce reported optimal health in a mere 43% of the population. The health metrics denoting cardiovascular health included smoking, body mass index, diet, physical activity, blood pressure, cholesterol, and blood glucose (Cash et al., 2019). While the evidence is synonymous regarding the disparity, there is a lack of insight into the contributing organisational, geographical, and personal factors underpinning this theme. One identified contributor is that of the organisational parameters of shift scheduling and the influence on worker health. The literature is unanimous that there is a need for organisational input to be able to implement custom designed workshops, psychoeducation, and contemporary psychological treatment modalities (Courtney et al., 2013). Stress is also a well understood factor of poor health and the rationale for this stress has been shown in qualitative data to differ greatly between each cohort. Rural paramedics cited poor flexibility to change shifts, traumatic cases, and organisational pressure while urban paramedics highlighted a large workload as their causative factor (Alanazy Ahmed Ramdan et al., 2021). However, it is noted that the assessment and conceptualisation of stress does vary across studies. While the specific influences on the paramedics' health is not reported in the review, the high rates of mental health disorders, sleep disorders, cardiovascular disease, and low levels of physical activity are widely reported between the rural and urban regions. These are at elevated rates in the rural paramedic workforce highlighting a key disparity between the subset locations.

DISCUSSION

The aim of this scoping review was to investigate the disparities that exist among the paramedic population based on geographical location and the influence that rurality has on this. This review has identified several disparities among the rural and urban paramedic population including disparities in the skills and confidence of the paramedic workforce, workload, caseload, resourcing, response, and travel times as well as the health status of paramedics. Upon further research these disparities appear to be systemic across other health services and areas of employment and highlight the impact the geographical divide has on public and private sector workforces.

Disparities in skills and confidence within the workforce between rural and urban locations is something which literature identifies as occurring among more than just the paramedic population. Rosvall (2020) examines the disparities between the types of skilled work carried out overall between rural and urban areas and found that people residing in urban areas generally have a higher prevalence in engaging in higher-skilled career paths such as scientists and engineers. In contrast it was also found that the rural locations had what was perceived as lesser-skilled career paths such as machinists and laborers (Rosvall, 2020). Similarly, Bennett et al. (2020) conducted a study in America which identified that urban emergency departments had more board-certified emergency medicine physicians than in rural areas indicating a disparity in the skill proficiency between these areas. More recently, this has again been seen in a study conducted by Kett, Bekemeier, Patterson, and Schaffer (2023) comparing the workforce competencies and training needs between rural and urban public health in the United States. However, whilst this study found that urban areas had greater skills relating to decision-making, health equity, diversity, and inclusion, rural areas were better in community engagement and cross-sectorial partnerships. This indicates that not all disparities between rural and urban healthcare were at the disadvantage of the rural location, however this is not something which was identified in the paramedic population in the literature reviewed for this study.

Furthermore, the disparity between rural and urban paramedics' caseload, workload, and access to resources to carry out operational duties was also evident in the literature. A difference in the number of cases between rural and urban areas can also be seen in other medical professions and is displayed throughout Cosgrave, Hussain, and Maple (2015) who completed an Australian study looking into the retention of mental health staff in rural New South Wales (NSW). This study found that rural staff believed they had a higher workload in rural areas than urban areas which is also consistent with Steinhaeuser, Joos, Szecsenyi, and Miksch (2011) whose comparison of rural and urban general practitioners (GPs) in Germany found that rural GPs were working an average of four more hours a week than urban GPs. This trend is also displayed across Malatzky and Bourke (2018) and McGrail, Humphreys, Joyce, Scott, and Kalb (2012) who focus on the challenges faced by Australian rural health professionals, with GPs concluding that the workloads and number of patients seen in the rural cohorts was greater than the urban areas studied.

When looking into the type of work carried out, Anderson, Saman, Lipsky, and Lutfiyya (2015), another study comparing the differences between rural and urban healthcare professionals in Mexico and Alaska, highlight the variation in the type of work carried out in the different geographical locations. This study found rural locations had a higher incidence of substance abuse and economic disadvantage and were more culturally diverse when compared with urban locations (Anderson et al., 2015). Similarly to the resource inequities which were seen between rural and urban paramedics, Cosgrave et al. (2015) show that this carries over into other health professions suggesting that an influence of mental health workers leaving rural areas in favour of urban locations is due to fewer resources in the way of service referral options. Additionally, Anderson et al. (2015) also comment on rural healthcare providers having access to less resources than urban areas, ultimately limiting the provision of specialised care. Overall, there is quite a similar representation of disparities relating to rural/urban caseload, workload, and resource allocation in multiple health professions as identified in the paramedic profession.

One of the most obvious differences between rural and urban paramedic work was the increased distance and therefore time taken to reach and transport patients (Spencer-Goodsir, Anderson, & Sutton, 2022). This disparity was frequently discussed in the literature located in this scoping review, particularly in relation to response times and transport times being extended (Alanazy Ahmed Ramdan et al., 2021; Ashburn Nicklaus et al., 2022; Ashburn et al., 2020; Cui Eric et al., 2021; Lu & Davidson, 2017; Newgard Craig et al., 2017; Stopyra et al., 2022).

This increased driving time is not unusual in literature related to emergency services and has been related to distance from services in literature related specifically to paramedic transport in rural areas (Adeyemi, Paul, & Arif, 2022; Miller, James, Holmes, & Van Houtven, 2020; Smith, English, Whitman, Lewis, & Gregg, 2022). Discussion about adverse terrain indicates that such driving conditions can be dangerous, particularly in rural and remote areas with poor road conditions, lighting, and adverse weather conditions, however urban areas also have issues related the possibility of additional vehicles being involved or traffic congestion (Liu, 2022; Spencer-Goodsir et al., 2022; Wubben, Denning, & Jennissen, 2019). Similar issues have also been identified in literature related to firefighting, where response times are also considered to be important (Wan Jusoh et al., 2023). Issues of fatigue increase workplace safety considerations, especially related to driving during "irregular hours," during shift work, or even after a shift has been completed, and are more likely in rural areas due to the amount of time spent driving during a shift. This is further discussed in the literature related to police services (Taylor, 2020) and taxi driving (Mahajan & Velaga, 2022) and specifically to rural paramedics (Courtney et al., 2013; Pyper & Paterson, 2016).

Lastly, the health disparities identified in the evidence base are ubiquitous that populations living or employed in rural areas are at a disadvantage compared to their urban counterparts. The data is skewed to increased rates of mortality and morbidity with an increased rate of hospitalisation (Mitchell & Lower, 2018). While this is generalised to the greater population of these locations, the evidence is supported among allied health professionals. Tham, Pascoe, Willis, Kay, and Smallwood (2022) identified that there was a statistically significant higher prevalence of mental illness in the rural workforce despite a reduced workload compared to the urban healthcare worker (Tham et al., 2022). The evidence is congruent with this among other emergency personnel and is seen in Johnson et al. (2020) who also identified rural firefighters as a particularly vulnerable subgroup for mental health related illness requiring specific intervention. This study highlighted that this subgroup was less likely to engage in treatment compared to urban personnel which may be due to the unavailability of empirically-based treatments in the regions (Johnson et al., 2020). Similarly, data has been found among the police and child protection workforces as shown in the findings of Roberts et al. (2021) that the rural professionals had higher rates of stress and burnout which was suggested to be related to organisational factors (Roberts et al., 2021). Overall, whilst this study has shown a significant disparity between paramedic health in rural and urban areas, literature from other emergency service professions indicates that this disparity may be common to other professionals.

LIMITATIONS

When examining the available literature, there was very limited research that explicitly explored the differences between the rural and urban paramedic workforce. As paramedicine is an emerging profession the number of articles reviewed were generally small. It is also possible that while the search terms of the strategy were broad, the authors may not have captured all available literature. Cross-national findings were reviewed of comparable pre-hospital emergency systems; however, only studies published in English were included potentially limiting results. It is worth noting that there is no consistent definition of rurality and for the purposes of this review all definitions were accepted despite the inconsistencies.

CONCLUSION

Through the literature identified in this scoping review, it was established that there were several disparities present amongst the rural and urban paramedic workforce. This was represented through differences in skills and confidence which showed lesser opportunities for a more advanced skill set in rural locations. Access to resources and varied workloads/caseloads was another prominent difference which ultimately saw the rural locations having to cover a geographical location larger in size with a greater caseload and less resources per capita than their urban counterparts. Both response time and transport times were seen to be generally greater in rural locations, and lastly, the overall health status of paramedics was seen to be generally poorer in rural areas.

This review has been able to ascertain that there are disparities present between the rural and urban paramedic locations to the degree that it is detrimental to providing good patient centred care. There is some evidence to suggest there has been an attempt to address these disparities, more specifically the issues of lesser resources in rural areas through dual dispatch of other emergency services. However, this was shown to have limited impact in rural areas despite showing benefits in urban locations.

This is why further research is highly recommended to establish the reason why these disparities exist and determine if it is due to lack of financial funding to rural areas, money being focused on the wrong services, or the fact that these disparities have gone by unnoticed. It is important to investigate the extent to which these disparities are impacting the lives of paramedics and the provision of emergency healthcare to explicitly target areas where patients and employees need further support including resources, upskilling, and education to achieve equity in the paramedic workforce across these two geographical divides.

Author(s) & year of publication	Aim	Participant characteristics	Methods	Relevant Findings	Theme(s)
Aftyka A, Rybojad B, Rudnicka-Drozak E. 2014.	Compare interventions in urban and rural areas by paramedics with particular emphasis on response time and on-site rescue activities.	All emergency medical teams were included from two emergency medical service substations in Poland.	Retrospective analysis of 1624 EMS events from two emergency medical service substations in Poland.	Urban areas had shorter response times and distances were usually less than 10 km while in rural areas less than 10 km in distance was found in only 7.2% of cases. Paramedics more often acted exclusively on site or ceased interventions in rural areas. Rural areas associated with increased use of collars and decreased use of intravenous access.	2,3
Alanazy ARM, Fraser J, Wark S. 2022. Saudi Arabia	Investigate EMS cases that resulted in non-transports in the urban and rural areas of Saudi Arabia.	Randomly drawn sample of de-identified patient records from the primary provider EMS service in Saudi Arabia.	Retrospective, cross-sectional study of 800 records over 12 months. A random sampling method was used to select records and data analysed.	Case presentation did not differ between areas, and the most common reason for non-transport in both areas was refusal of treatment and transport. Of the 310 non -transports across locations, 10 were treated on scene and released by rural EMS while no urban patients were treated and released.	3
Alanazy ARM, Fraser J, Wark S. 2021. Saudi Arabia	To gain insights from frontline workers about organisational factors impacting on discrepancies in rural and urban EMS outcomes.	20 participants employed by Saudi Red Crescent EMS as technician (6 rural; 4 urban), paramedic (0 rural; 3 urban), or EMS station manager (4 rural; 3 urban), all with a minimum of 5 years experience with the EMS; total of 10 rural and 10 urban.	Semi -structured interviews in Arabic, translated to English between 2019 – 2020 until data saturation was reached. Hermeneutic phenomenology with Braun & Clarke's thematic analysis.	Three themes: organisational factors;, EMS personal issues, and patient factors. This article reports on organisational factors only. Variations between rural and urban areas included longer response and transport time in rural areas, but also impacted on by traffic in urban areas. Some rural areas required 4x4 vehicles and GPS and had limited services available. Rural areas were more likely to have trauma whilst urban areas were more likely to be medical. Skilled paramedics were less likely in the rural areas, impacting on scope of practice. Similarities between rural and urban areas included poor coordination between services and high numbers of non-urgent callouts.	1,2,3,4
Alanazy A, Fraser J, Wark S. 2021. Saudi Arabia	To determine issues influencing work practices of EMS personnel in Saudi Arabia.	EMS personnel (frontline paramedics and emergency medical technicians, and mid-level station managers) from Saudi Red Crescent working in rural and urban areas in Riyadh. Minimum of five years experience in EMS. Participants all male.	Hermeneutic phenomenology design. Semi-structured interviews. Interview guide based on findings of previous quantitative research. Interview focus on identifying areas for improvement not on experience of work. Interview guide piloted. Follow -up interview conducted after analysis. Thematic analysis (Braun & Clarke).	20 interviews (10 urban, 10 rural). EMT's 10, paramedics 3 (all urban), and managers 7. Main themes impacting delivery of EMS services: factors related to EMS personnel, patients, and organisation. Sub-themes included working conditions, stress, education, and training and resources. Specific geographical issues: lack of education opportunities in rural areas, paramedic training only available in urban areas, challenges accessing patient, more trauma calls in rural areas, more medical calls in urban areas, lack of trauma facilities or air support in rural areas so longer travel times, less stations / /staff in rural areas, reduced access to equipment, equipment that is older or not suited to the unique challenges of the rural environment, staff retention harder in rural areas (burnout) and staff dependent on volunteer assistance. Local training to reflect local caseload would be beneficial. Quality of urban and rural EMS services impacted by organisational factors. Recommendations to address identified barriers include policy change (increased female recruitment), enhanced training for rural personnel, increased public awareness of EMS role.	1,3,4
Alanazy ARM, Wark S, Fraser J, Nagle A. 2020. Saudi Arabia	Examine the utilisation of prehospital EMS resources across rural and urban areas.	Random sample of rural and urban patient care records from the Saudi Red Crescent Authority EMS. 559 men and 241 women patients were sampled.	Cross-sectional study utilising random sampling of electronic databases.	Deaths on scene were higher in rural areas than urban areas, however overall death rate was low between the two. Urban areas workload consisted more of medical cases whereas rural areas had a 50/50 split of medical and trauma cases. Rural patients were more likely to experience fractures/ lacerations and head injuries, Urban patients more frequently endured wounds/burns. Nil significant difference in airway, breathing, extrication, and immobilisation treatment; however, urban patients were significantly more likely to receive circulation treatment. Rural patients were five times more likely to receive advanced treatment over urban patients; however, overall numbers were still small.	3

Table 2. Summary of characteristics articles included.

Author(s) & year of publication	Aim	Participant characteristics	Methods	Relevant Findings	Theme(s)
Ashburn NP, Hendley NW, Angi RM, Starnes AB, Nelson RD, McGinnis HD, et al. 2020. USA	To investigate scene time and transport time in adult and paediatric trauma patients.	Adult & paediatric trauma patients transported to Level I and Level II trauma centres by ground, ambulance under emergency conditions. 2179 patient records identified. 2077 patient records included in analysis. 92.4% (n=1919) adult, 7.6% (n=158) paediatric. 68.8% (n=1428) males. Excluded non-emergency transports and patients deceased on scene.	Retrospective cohort study of penetrating and blunt trauma patients transported to Level I and Level II trauma centres by ground ambulance under emergency conditions over five-year period (2013-2018). Cohort drawn from regional and multijurisdictional area (five counties across North Carolina) served by ALS-level EMS agencies. Two counties included urban centres. Geographic categories determined by the Centres for Medicare and Medicaid Services Ambulance Fee Schedule (AFS). Descriptive statistics and linear mixed-effects modelling.	80.6% (n=1675) blunt injury, 19.4% (n=402) penetrating injury. 20.1% (n=416) rural. Target scene time goal of 10 mins exceeded in 64.7% of cases. Mean scene time 14.2 minutes. Mean transport time 17.5 minutes. Scene time for adult trauma patients, blunt and penetrating, significantly greater than scene time for paediatric trauma patients. Shorter scene times for paediatrics, males, penetrating injury, blunt trauma in rural areas. Transport time for adult trauma patients, blunt and penetrating, comparable with transport time for paediatric trauma patients. Shorter transport times for males, non-white patients, patients in urban areas.	2
Ashburn NP, Snavely AC, Angi RM, Scheidler JF, Crowe RP, McGinnis HD, et al. 2022. USA	To quantify differences in rural and urban areas for prehospital times for cardiac patients.	ESO Data Collaborative dataset of 1332 EMS agencies, a total of 428 ,054 encounters during 2013-2018. 10.3% were rural. Rural areas were defined as less than 2 ,500 people.	Statistical analysis including generalised estimating equation.	Rural cases had a median response time of 10.0 min in comparison with 5.0 min in urban areas. Median scene time 16 min rural; 16 min urban. Median transport time 27.0 min rural; 12 min urban.	2
Bush M, Glickman LT, Fernandez AR, Garvey JL, Glickman SW. 2013. USA	Identify patient, geographic and EMS agency related factors associated with failure to perform a prehospital ECG.	Data from the Prehospital Medical Information System in North Carolina Patients greater than 30 yrs and had a prehospital complaint of chest pain.	Retrospective cohort Study. Data obtained was entered using a web-based interface or exported by EMS agencies using commercial software which was certified compliant.	Lowest proportion of prehospital ECG utilisation was found to be in the most rural populations. Persons with less transport times were significantly less likely to have a prehospital ECG conducted than longer transport times. Biggest barrier to performing prehospital ECGS was found to be the under availability of ECG equipment and Ems certification which was more prevalent in rural areas. This study recommends increased ECG equipment availability and training in rural areas particularly due to a higher probability of having a non-paramedic crew in these areas.	2,3
Cash RE, Crowe RP, Bower JK, Foraker RE, Panchal AR. 2019. USA	Compare the distribution of cardiovascular health metrics between EMTs and paramedics and identify associations between demographics and employment characteristics.	Nationally certified emergency medical service professionals. 24,708 EMS professionals were surveyed and included in the study.	Cross sectional survey based on the American Heart Association's Life's Simple 7 with multivariable logistic regression analysis to estimate odds ratios.	Factors associated with optimal cardiovascular health included education level, higher personal income and working in an urban versus rural area (OR = 1.31).	4
Clark DE, Winchell RJ, Betensky RA. 2013. USA	To determine the effect of emergency care on patient outcomes related to traffic injuries.	Pre-existing data from 2002-2003 Fatality analysis Reporting System which collates national data from the USA.	A variety of statistical analyses including regression modelling.	Increased hazard with rural location. First 30 min of EMS intervention beneficial for patients, but not for those who do not reach a hospital within that 30 min timeframe. Despite the impact of delay crash prevention is a more effective strategy.	2,3
Coleman N, Barry T, Tobin H, Conroy N, Bury G. 2019. Ireland	To explore training, clinical practice, and experience of Irish Advanced Paramedics (APs) in paediatric airway management and to examine attitudes of clinicians.	Graduates of AP training program at University College Dublin (n=453). Sample of 382 contacted. 75% of AP respondents based in urban or mixed environments.	Anonymous survey. Survey piloted. Survey not validated.	Response rate of 48%. 70% of participants exposed to paediatric case requiring airway management, but only 23% had formal training to manage this. 40% of population rural. Challenges related to response times, transport times, and high risk of skill erosion due to infrequent exposure. 85% wanted refresher training in the hospital environment.	1,2,3
Connolly MS, Goldstein PJP, Currie M, Carter AJE, Doucette SP, Giddens K, et al. 2022. Canada	Investigate the differences in OHCA survival between urban centres and rural areas.	Data collected from Emergency Health Service electronic patient care record system.	Retrospective cohort study over 12 months with multivariable logistic regression covariates.	Paramedic response time was shorter in urban than rural areas as well as estimated time to defibrillation resulting in a higher number of ROSC in urban areas. Throughout the study urban and rural areas had a similar number of shockable rhythms, rural areas had less defibrillation resulting in ROSC. Rural mean time to defibrillation = 17.2 mins, urban mean time to defibrillation = 10.8 mins.	2

Table 2 (cont.). Summary of characteristics articles included.

Author(s) & year of publication	Aim	Participant characteristics	Methods	Relevant Findings	Theme(s)
Courtney JA, Francis AJP, Paxton SJ. 2013. Australia	Investigate sleep quality, fatigue, mental health, and physical activity in rural paramedics.	150 Paramedics were recruited from Victoria in Australia and was voluntary and limited to active personnel who worked a rotating roster with a night shift component. 73.1% of respondents were male and 26.5% female.	Cross sectional survey study. Regression analysis of variables within survey and reference groups from previously published studies.	Significantly higher rates of fatigue, anxiety, stress, and poorer sleep quality in rural paramedics in comparison to similar reference group samples. Rural paramedics also reported less physical activity. Nil significant differences in depression were found.	4
Cui ER, Fernandez AR, Zegre-Hemsey JK, Grover JM, Honvoh G, Brice JH, et al. 2021. USA	Evaluate EMS response, scene, and transport times and adherence to proposed time benchmarks for patients with suspected ACS.	EMS suspected patients with ACS defined as a complaint of chest pain or suspected cardiac event with documentation of myocardial ischemia or prehospital ECG or prehospital activation of the cardiac care team. 4667 patients met the eligibility criteria.	Population -based, retrospective study with the North Carolina Prehospital Medical Information System analysing EMS data from 2011-2017.	Scene times were comparable however patients in rural counties experienced longer response and transport times. ECG findings of ischemia were more frequent in rural (77%) than urban (41%). Morphine use occurred twice as often in rural (19%) than urban (9%). STEMI centre activation was different with urban (71%) and rural (49%).	2,3
Deeb A-P, Phelos HM, Peitzman AB, Billiar TR, Sperry JL, Brown JB. 2020. USA	Evaluate differences in prehospital under triage in rural settings versus urban settings.	Adult patients in the Pennsylvania Trauma Outcomes Study from 2000-2017 were included which included 453,112 patients.	Retrospective mixed methods study of a registry between 2000-2017.	Under triage was higher in rural patients (8.6% compared to 3.4%). Lack of a rural trauma centre requiring transfer to an urban centre is a risk factor for under triage.	1,3
Emond K, Bish M, Savic M, Lubman DI, McCann T, Smith K, et al. 2021. Australia	Examine the perceived confidence and preparedness of paramedics in Australian metropolitan and rural areas to manage mental health related presentations.	On road paramedics were sought from five states and one territory. All paramedics across these services were invited to apply. Participants ranged from 21 to 67 years and 66.1% of participants were male compared to 36.4% female.	Cross -sectional study with an online survey of 1140 paramedics nationwide over eight months.	Rural and regional paramedics were generally older with fewer qualifications and were significantly less confident and less prepared to manage mental health presentations ($p = 0.001$) than metropolitan counterparts. Females were less confident than men ($p = 0.003$) although equally prepared to manage mental health ($p = 0.1$).	1,4
Hegenberg K, Trentzsch H, Gross S, Pruckner S. 2019. Bavaria	Investigate utilisation trends between rural and urban municipalities as well as events with and without prehospital emergency physicians dispatched.	Ambulance dispatch data collected between 2007 and 2016 in Bavaria from 26 dispatch centres. Locations were classified into five levels of rurality.	Retrospective observational study utilisation negative binomial mixed effects regression models to investigate differences and utilisation trends. Graphical representation methods used to compare distribution of transport rates and distribution across time.	In Bavaria the number of emergencies with a prehospital emergency physician (PEP) dispatched was 1.5 times higher in large cities than rural areas. Transport rates were similar between rural and urban areas when a PEP was dispatched however, transport rates were higher in rural areas then a PEP was not dispatched. There were a higher number of emergencies in the urban areas during the day this was inferred to be due to the daytime population density increasing due to inbound commuters. Limitation: The authors of this study recognise that they fail to provide explanations and causes for these trends and that these may only be applicable to Bavaria and may not be transferable to other regions with differing healthcare infrastructure and population composition.	3
Hodell E, Hughes SD, Corry M, Kivlehan S, Resler B, Sheon N, et al. 2016. USA	Understand the challenges and barriers faced by paramedics in recognising stroke presentations prehospitally.	28 participants; Paramedics from 12 EMS agencies in rural, urban, and suburban communities.	Thematic analysis from 12 emergency medical service agencies from urban and rural communities. Transcripts were subjected to deductive and inductive coding.	Language barriers were noted in urban areas as an impairment to recognising stroked prehospitally. This was not mentioned in the rural environment. A rural participant acknowledged that stroke calls are rare, and both rural and urban paramedics acknowledged the importance in feedback in improving their recognition of strokes prehospitally; it was identified that this was easier in rural than metropolitan areas.	1
Hsu Y-C, Wu W-T, Huang J-B, Lee K-H, Cheng F-J. 2021. Taiwan	Examine the relationship between outcomes of out of hospital cardiac arrests and the patient's underlying pathology and in urban areas versus rural areas.	Study was conducted in Kaohsiung, which has the second highest population in Taiwan, and all patients that had an out-of-hospital cardiac arrest and were treated by EMS were examined.	Univariate and multivariate logistic regression analyses of 4225 cases from EMS databases between January 2015 and December 2019.	Urban areas were a prognostic factor for more than 24-hour survival (CI = 1.179-1.761). EMS response timing was quicker and rate of attendance by paramedics was higher in urban settings ($p < 0.001$). EMS response time was an independent risk factor for survival to hospital discharge.	2

Table 2 (cont.). Summary of characteristics articles included.

Author(s) & year of publication	Aim	Participant characteristics	Methods	Relevant Findings	Theme(s)
Lee E, McDonald M, Oâneill E, Montgomery W. 2021. Canada	Evaluate pilot community paramedicine (Connolly et al.) programs from paramedic perspectives to gain recommendations from both rural and urban settings.	Online questionnaire . 158 participants with and without CP experience. 75 participants had self -identified as having CP experience with 6-12 months being the average length of time CP had been practiced at the time of questionnaire completion. 41 of these were from rural areas.	Mixed-methods sequential explanatory study.	Urban CP programs usually have dedicated CPs who devote their whole shift to CP duties. In rural CP programs it is more common for paramedics to undergo both CP work and EMS work in the same shift. Urban paramedics were found to be more positively receptive to CP compared to rural paramedics who preferred EMS duties when asked to choose between the 2. Both rural and urban paramedics preferred to be able to carry out both CP and EMS duties in the same shift. Limitation: CP was only initiated in some areas for a few months before the questionnaire was released.	3,4
Irvine R, Doan T, Bosley E, Colbeck M, Bowles KA. 2022. Australia	To determine epidemiological patterns and characteristics of paediatric OHCA. Prevalence of aetiologies across different groups.	OHCA over 10-year period (2009 - 2019). 1612 patients attended by QAS. Patients up to 18 years. Neonates excluded.	Retrospective analysis of QAS OHCA database.	Lower rate of ROSC in rural areas (20% v 32% urban). More traumatic OHCA in rural areas (26% v 16% urban). 25% achieve ROSC. ROSC higher in urban (32% v 20% rural). Disparities between rural and urban outcomes across age ranges. Disparities in paramedic scope (CCP 92% urban v 63% in rural). Response times similar in rural and metro areas. Better outcomes for witnessed OHCA with defibrillation.	1,2,3
Jegasothy E, McGuire R, Nairn J, Fawcett R, Scalley B. 2017. Australia	Estimating impact of heat and cold events on the utilisation of health services across NSW (ambulance calls, ED visits and mortality).	10-year period (2005 – 2015). NSW – urban, regional, and rural locations.	24 Poisson time-series regression models. Reviewed data on ambulance calls, ED visits and mortality.	Almost 70% of data related to urban areas. Heat waves resulted in a statistically significant increased utilisation of health services. Gradient increases with severity. Cold waves did not have a statistically significant effect on health service utilisation, except in outer regional / remote areas. Ambulance calls did not vary across geographical areas during heat or cold waves. ED presentations and mortality differed between locations. Urban and rural areas may need to prepare in different ways. Low intensity heat waves have greater impact in rural areas leading to excess strain on healthcare system in areas with limited resources (ambulances). Cold waves impact more on ED than on ambulance calls.	3
Lu Y, Davidson A. 2017. USA	To understand the need for and access to EMS.	Fatal motor vehicle accidents (n= 10 ,132) in Texas 2006-2008 from the Fatality Analysis Reporting System.	Statistical analysis of distribution of fatal motor vehicle accidents in Texas from a spatial disparity perspective.	Service areas were larger in rural rather than urban areas. Rural areas had greater fatality rates. Average response times urban 7.19; rural 14.85 min; Average transport time urban 27.85; rural 39.24 min;.	2
Martin LK, Lewis VJ, Clark D, Murphy MC, Edvardsson D, Stub D, et al. 2020. Australia	Factors hindering paramedics and emergency nurses managing STEMIs in rural and metropolitan hospitals.	333 respondents; 293 paramedics; 101 metropolitan paramedics; 209 regional/rural paramedics.	79 item online survey, with descriptive statistics and exploratory factor analysis.	All metropolitan and regional/rural respondents were combined, i.e.., cannot separate paramedics from nurses, however as there were significantly more paramedics than nurses this is still relevant. 73% of metropolitan; 49% regional/rural indicated poor handover in the cath lab environment. Regional/rural paramedics more likely than metropolitan counterparts to complain about too many policies related to STEMIs; inability to achieve commitment to guidelines, e.g.., due to distance, lack of services or being sole practitioner; limited resources; poor hospital coordination, e.g.., off-loading patients; lack of confidence with complex patients; and a lack of reliability within algorithms.	1,3
Masuda J, Kishi M, Kumagai N, Yamazaki T, Sakata K, Higuma T, et al. 2018. Japan	To investigate disparities in emergency care of AMI between rural and metro areas	AMI patients receiving PPCI within 24 hours. Rural cohort (1313) compared with metro cohort (2075). Data collected over a 1-year period (2013).	Observational study. AMI Registry from rural and metro areas used.	AMI patients in rural areas less likely to be transported direct to PCI centre leading to delays in PPCI (43% v 60%). Direct ambulance transport to PCI facility strongest predictor for OTB time <2 hours. Higher prevalence of co-morbidities in rural cohort. Rural cohort had longer hospital stays and higher mortality rates. OTB significantly longer in rural. Time to scene and on scene shorter in rural group but transport times longer.	1,2,3
Moafa HN, van Kuijk SMJ, Alqahtani DM, Moukhyer ME, Haak HR. 2020. Saudi Arabia	Examine differences in characteristics of jobs dispatched my EMS between rural and urban areas in Saudi Arabia.	The population -based registry included all missions deployed over one year in 2018.	Retrospective cohort study with statistical analysis.	Rural areas encountered male patients more frequently and female in urban areas. Urban areas demanded more medical emergencies, and rural encountered more traumatic emergencies. 67.8% of calls were for the high urgent category in metropolitan while rural was 50.8%	3

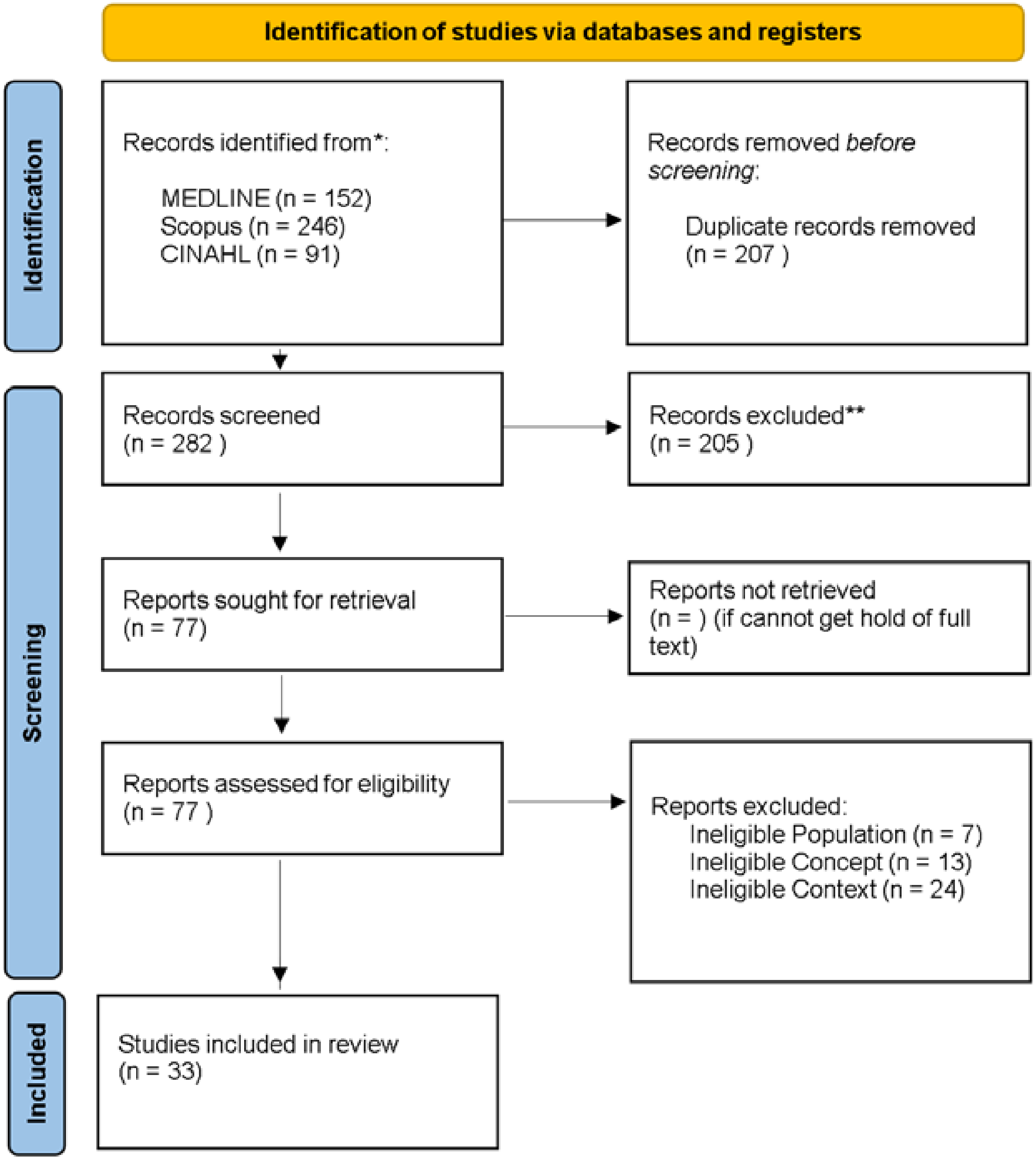
Table 2 (cont.). Summary of characteristics articles included.

Author(s) & year of publication	Aim	Participant characteristics	Methods	Relevant Findings	Theme(s)
Newgard CD, Rongwei F, Bulger E, Hedges JR, Mann NC, Wright DA, et al. 2017. USA	To describe and evaluate rural vs urban care, severity, and mortality among patients of EMS.	44 EMS agencies transporting 67 047 patients during 2015-2016; only 1 971 (2.9%) were rural Rural defined as 60 mins driving – different to other research.	Statistical analysis including stratified probability sampling.	Rural response and transport times longer, but on-scene time similar to urban. Death in rural areas more likely outside hospital, however mortality not significantly different overall – could be due to limited numbers of rural patients.	2
Nordberg P, Jonsson M, Forsberg S, Ringh M, Fredman D, Riva G, et al. 2015. Sweden	Determine the effects of dual dispatching on response times and region outcomes in OHCA.	OHCA data from January 2004 – -December 2009 divided into 4 subgroups (rural, suburban, urban, and downtown) Patients were greater than 8 years old and cardiac arrest was assumed to be of a cardiac nature and was not witnessed by an EMS crew.	Prospective cohort study and characteristics of each case collected from the Swedish Cardiac Arrest Register. All comparisons of proportions were tested using the Wald Chi-Square test.	This article shows that dual dispatch improves patient outcomes. Dual dispatch of firefighters or police in addition to EMS in cases of OHCA has been shown to reduce response times and has been associated with improved survival rates. The 30-day survival increased significantly in the downtown and suburban populations, while a limited impact was seen in the rural areas. Firefighters were first on scene in 54% rural cases and 27% in downtown area. Dual dispatch significantly reduces response times in all regions (EMS response times remained the same throughout).	2,3
Ro YS, Shin SD, Song KJ, Lee EJ, Kim JY, Ahn KO, et al. 2013. South Korea	Understand trends in outcomes of EMS OHCA according to the community urbanisation level.	Nationwide OHCA database in South Korea including information on demographics. Case sheets from 2006-2010 were reviewed of 119 ambulances operating during this time.	Retrospective nationwide observational study. The outcomes were calculated compared to a standard population.	Median response time 9 min 30 sec in rural areas, 7 min 23sec in urban areas, 6 min 20 sec in metropolitan areas. Transfers to Level 1 and Level 2 Emergency departments were 14.6% rural, 43.4% urban, 65.4% metropolitan. OHCA results in rural areas did not improve over the study period whilst they did in urban and metropolitan areas. This is assumed to be due to improvements made in urban and metropolitan communities but not rural areas suggesting major improvements in EMS resources, quality, CPR techniques, and hospital post- ROSC care have not occurred equally amount these areas.	2,3
Sariyer G, Ataman MG, Sofuoalu T, Sofuoalu Z. 2017. Turkey	Characterise ambulance utilisation rates between rural and urban areas and investigate associated factors.	Total emergency demand was analysed, and data categorised into four sub-categories: gender, age, rural-urban, and reason for the call. All non-emergency calls were excluded.	Retrospective mixed methods study drawn from the State Provincial Health Directorate ambulance services during 2013.	The absolute number of calls from rural regions was less than urban but the rural regions had a higher proportion of calls (i.e., calls per 1000 people). Significant but negative relations identified between rural and urban demand.	3
Stopyra JP, Crowe RP, Snavely AC, Supples MW, Page N, Smith Z, et al. 2022. USA	To examine disparities in prehospital times for rural STEMI patients.	Data collected from 23,655 STEMI patients.	Analysis of prehospital patient database over a 2-year period (2018 & 2019). 1366 emergency service agencies provided access to databases.	EMS intervals significantly longer in rural areas. 60% less likely to meet 60 min target. 8.4% (1994) of participants were rural areas. Increased annual mortality in rural areas. 1/3 of rural patients did not receive a 12-lead ECG within 10 mins on scene. Rural patients less likely to meet the 15 min on scene target.	2,3
Wong HT, Lin T-K, Lin J-J. 2019. Taiwan	To assess differences in demand and misuse of the Emergency Ambulance Service (EAS) rural and urban areas of New Taipei City, Taiwan.	160 ,000 EAS usage records of 67 EAS units extracted from New Taipei City Fire Services Department Misuse was classified as Triage categories 4 and 5.	Statistical analysis – negative binomial regression model.	Rural areas had a significantly higher EAS demand per capita than urban areas. Rural areas showed a link between a lack of medical resources and misuse.	3
Yeap E, Morrison J, Apodaca A, Egan G, Jansen J. 2014. Scotland	Determine the effect of rurality on the level of destination healthcare facility and ambulance response time for Scottish trauma patients.	Prehospital data collected by the Scottish Ambulance Service form 2009-2010 . Data composed of 50.5% male, 48.2% female, and 1.5% gender not recorded . Median age 59 years.	Retrospective analysis of prehospital data. Locations characterised using the Scottish urban/rural classification.	Remote locations are disadvantaged due to prolonged pre-hospital response times, in addition to being transported to hospital which are not as well-resourced in comparison to more urban areas. Call out times increase with degree of rurality as well as travel times. Regionalisation of trauma care and enhanced retrieval capability may improve these disparities. Limitation: This study uses the Scottish urban/rural classification which may not be comparable to other countries.	2
Reference: Theme 1: Skills and Confidence of the Workforce Theme 2: Resourcing Theme 3: Timing Theme 4: Paramedic Health Status					

Table 2 (cont.). Summary of characteristics articles included.

#	Query	Results
	MEDLINE ALL (includes MeSH headings) [1946 to Present] (Ovid). Searched 25/01/2023.	
1	(urban or metro*).ti,ab.	209,181
2	(rural or remote or regional).ti,ab.	459,540
3	Emergency Medical Technicians/ or (paramedic* or ambulance or EMT or emergency medical technician* or prehospital or pre-hospital or out of hospital).ti,ab.	66,891
4	(Comparison* or imbalance* or disparit* or differ* or dissimilar* or contrast* or variation*).ti,ab.	7,945,769
5	1 and 2 and 3 and 4	301
6	limit 5 to (english language and yr="2013 - 2023" and journal article)	152
	CINAHL Plus with Full Text (EBSCOhost). Searched 25/01/2023.	
S1	((MH "Urban Areas") OR (TI (urban OR metro*)) OR (AB (urban OR metro*)))	89,452
S2	((MH "Rural Areas") OR (TI (regional OR remote OR rural)) OR (AB (regional OR remote OR rural)))	155,143
S3	(MH ("Emergency Medical Technicians" OR "Prehospital Care") OR paramedic* OR ambulance OR EMT OR "emergency medical technician*" OR prehospital OR pre-hospital OR "out of hospital" OR out-of-hospital)	47,980
S4	((TI (Comparison* OR imbalance* OR disparit* OR differ* OR variation* OR distinction* OR dissimilarit* OR effect* OR experience*)) OR (AB (Comparison* OR imbalance* OR disparit* OR differ* OR variation* OR distinction* OR dissimilarit* OR effect* OR experience*)))	2,594,650
S5	S1 AND S2 AND S3 AND S4	282
	S5 limited to 2013-2023, English Language, Peer Reviewed, Journal Article	91
	Scopus. Searched 25/01/2023.	
1	ABS (urban OR metro*) AND ABS (rural OR remote OR regional) AND ABS (paramedic* OR ambulance OR emt OR {emergency medical technician} OR {emergency medical technicians} OR prehospital OR pre-hospital OR {out of hospital} OR out-of-hospital) AND ABS (comparison* OR imbalance* OR disparit* OR differ* OR variation* OR distinction* OR dissimilarit* OR effect* OR experience*) AND (LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j"))	246
	Total from all databases:	**489**
	Total after duplicates removed:	**282**

Appendix 1. Queries and results.



Appendix 2. PRISMA-ScR (Page, 2020).
*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

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RESEARCH REPORT

CORRELATION BETWEEN SHOCK INDEX AND MORTALITY IN THE PREHOSPITAL AND LEVEL 1 RURAL TRAUMA CENTER EMERGENCY DEPARTMENT SETTINGS

Victoria Clancy, MD*[1], Matthew Leonard, MPA[1], J Bracken Burns, DO, MS[1,2]

Author Affiliations: 1. Ballad Health Trauma Services, Johnson City, TN, USA; 2. Department of Surgery, Quillen College of Medicine, East Tennessee State University, Johnson City, TN, USA

**Corresponding Author*: Clancy@etsu.edu

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ABSTRACT

Background: Trauma remains one of the leading causes of death in the United States. The shock index is a valid tool used to detect impending circulatory collapse in the prehospital setting. A ratio of ≥ 0.9 has been shown to have higher rates of mortality than a normal ratio of < 0.7. As validation of the shock index requires high sample sizes, the majority of retrospective studies have been performed at urban level 1 trauma centers. We hypothesized that the shock index would accurately predict mortality in a rural level 1 trauma center.

Objective: Determine if the shock index continues to be a reliable predictive value in trauma patients for morbidity and mortality in rural settings.

Setting: This retrospective study was performed at a state-designated level 1 trauma center in Johnson City, Tennessee. There were 5,090 patients included in the study. The shock index was calculated as heart rate/systolic blood pressure for all patients, both prehospital and on arrival to the emergency department. The patients were divided into three categories: SI ≤ 0.7, 0.71-0.89 and ≥ 0.9. We assessed the relationship between SI, blood product usage and outcome variables using Pearson's correlation coefficients and logistic regression. Chi-square analysis was used to examine the differences between mortality.

Results: Patients with a high SI after arrival to the ED experienced longer hospital stays, ICU and mechanical ventilation days, ISS and blood product usage. Mortality was higher in patients with a SI of ≥ 0.9 in both the prehospital and emergency department settings.

Conclusion: Access to trauma centers continues to be a major issue in the United States, causing overall longer transport times and time to definitive care centers. Based on our study, the SI remains a valid tool for predicting mortality at rural trauma centers, along with predicting need for blood products. With our data, we continue to recommend its usage in both urban and rural trauma centers.

INTRODUCTION

Trauma continues to be one of the leading causes of death in the United States. According to the American Association for the Surgery of Trauma (American Association for the Surgery of Trauma, 2020), it is the fourth leading cause of death for all ages, and the leading cause of death for individuals aged 1-45. However, it has been shown that many preventable deaths are related to a missed diagnosis of hemorrhagic shock (Eastridge, Holcomb, and Shackelford, 2019). The shock index (SI) was first described as means to improve the detection of impending circulatory collapse in the prehospital setting (Allgöwer & Burri,1967). The patient's vital signs, including heart rate and systolic blood pressure, were obtained by prehospital staff; the ratio of heart rate to systolic blood pressure was calculated and reported to the accepting facility. A ratio of > 0.7 was shown to have higher rates of morbidity than a normal ratio of 0.5-.0.7. The SI was later proven to be a valid marker for significant injury in trauma patients (King, Plewa, Buderer, and Knotts, 1996). Since that time, multiple retrospective studies have been performed that further validate the use of the SI in trauma patients as not only a marker for injury, but as a predictor of both inpatient morbidity and mortality (McNab, Burns, Bhullar, Chesire, and Kerwin, 2013). The use of the SI has been expanded into the treatment of patients with septic shock and pediatric patients. As validation of the SI requires high sample sizes, many retrospective studies have been performed at urban level 1 trauma centers. We sought to justify the use of the SI in a rural level 1 trauma center.

ETHICS STATEMENT

This study was approved with waiver of informed consent by the Institutional Review Board. The authors have reported no financial conflict of interest.

OBJECTIVE

The objective of this study was to determine if the shock index predicts morbidity and mortality in rural trauma patients.

METHODS

This was a retrospective study performed at a state-designated level 1 trauma center in Johnson City, Tennessee. The center primarily serves residents from rural areas, including Northeast Tennessee, Southwest Virginia, Kentucky and western North Carolina. All 5090 patients included in the study were treated by the trauma team between January 1st, 2016, and December 31st, 2019. Patients were excluded from the study if they were under the age of 18, transferred to another facility prior to arrival at our facility, or if insufficient data was available. Each patient's SI was calculated as heart rate/systolic blood pressure. Both the prehospital and emergency department (ED) SI were calculated, with the prehospital vital signs being the first recorded by Emergency Medical Services (EMS). The ED vital signs were the first recorded on arrival. Descriptive data for the patients included total hospital days (LOS), total mechanical ventilation days, total intensive care unit days, disposition, Injury Severity Score (ISS) and transfusion totals. Patients were divided into three categories: SI ≤ 0.7, 0.71-0.89, and ≥ 0.9. These ratios have previously been proven to show statistically significant differences in morbidity and mortality. We assessed the relationship between SI and outcome variables using Pearson Correlation Coefficients and logistic regression. Chi-square analysis was used to examine the differences between mortality and blood product usage based on SI value. The confidence level was set at 95%. Data were analyzed using Jeffrey's Amazing Statistics Program (JASP, (version 0.14.1.0)), an open-source program supported by the University of Amsterdam, along with Excel (version 2016).

RESULTS

The sex proportions in our population were almost equal (Males 50.5%, Females 45.5%). Males were the majority in groups 0.71- 0.89 and ≥ 0.9 both prehospital and emergency department arrival. In the prehospital setting this was 55.556% with a SI of 0.71- 0.89 and 56.042% with a SI of ≥ 0.9. In the Emergency department 57.157% with a SI of 0.71- 0.89 and 56.374% with a SI of ≥ 0.9.

The average age of patients prehospital was 63.9 (IQR 33, Std. 21.317) in the ≤ 0.7 SI group, 50.2 (IQR 36, Std. 21.512) in the 0.71- 0.89 SI group, and 48.2 (IQR 35, Std. 21.174) in the ≥ 0.9 SI group. In the ED, the average age of patients was 62.5 (IQR 34, Std. 21.710) in the ≤ 0.7 SI group, 49.2 (IQR 35, Std. 21.359) in the 0.71- 0.89 SI group, and 48.8 (IQR 35, Std. 21.398) in the ≥ 0.9 SI group.

Mortality

In the prehospital setting, patients were 29.5 times more likely to survive with a SI of ≤ 0.7, which was significant. Patients with a SI of ≥ 0.9 had a 75% significant increased risk of death. In the ED, patients were 33 times more likely to survive with a SI of ≤ 0.7, which was significant. Patients with an SI of ≥ 0.9 had a 40% increased risk of death, which was significant (Table 1).

	Odds Ratio (Odds of Survival)	P Values	Confidence Interval
Shock index (prehospital)			
≤ 0.7	29.563	< 0.001	2.937, 3.836
0.71- 0.89	1.302	0.199	0.139, 0.666
≥ 0.9	0.573 (75%)	0.047	-1.105, -0.007
Shock index (emergency department)			
≤ 0.7	33.125	< 0.001	3.160, 3.841
0.71- 0.89	0.913	0.645	-0.475, 0.294
≥ 0.9	0.294 (40%)	< 0.001	-1.723, -0.723

Table 1: Logistic regression of survival for prehospital and emergency department

Blood Products

In the prehospital setting, patients with a SI of ≥ 0.9 were 2.8 times more likely to require blood products, which was significant. In the ED, patients with a SI of ≥ 0.9 were 3.1 times more likely to require blood products, which was also significant. In both the prehospital and ED settings, patients with a SI of ≤ 0.7 had a significantly lower chance of requiring blood products during their hospitalization.

	Odds Ratio (Odds of Survival)	P Values	Confidence Interval
Shock index (prehospital)			
≤ 0.7	0.07	< 0.001	-2.994, -2.337
0.71- 0.89	0.667	0.004	-0.681, -0.128
≥ 0.9	2.763	< 0.001	0.648, 1.385
Shock index (emergency department)			
≤ 0.7	0.093	<.001	-2.652, -2.109
0.71- 0.89	0.935	0.619	-0.329, 0.196
≥ 0.9	3.138	< 0.001	0.761, 1.526

Table 2: Logistic regression of blood product usage in the prehospital and emergency department.

We determined the direction of the relationships between the variables to SI for patients in the ED with a SI of ≥ 0.9. With this SI level, total hospital days showed a small increase as the SI increased ($r(352) = 0.2$, $P < 0.01$),

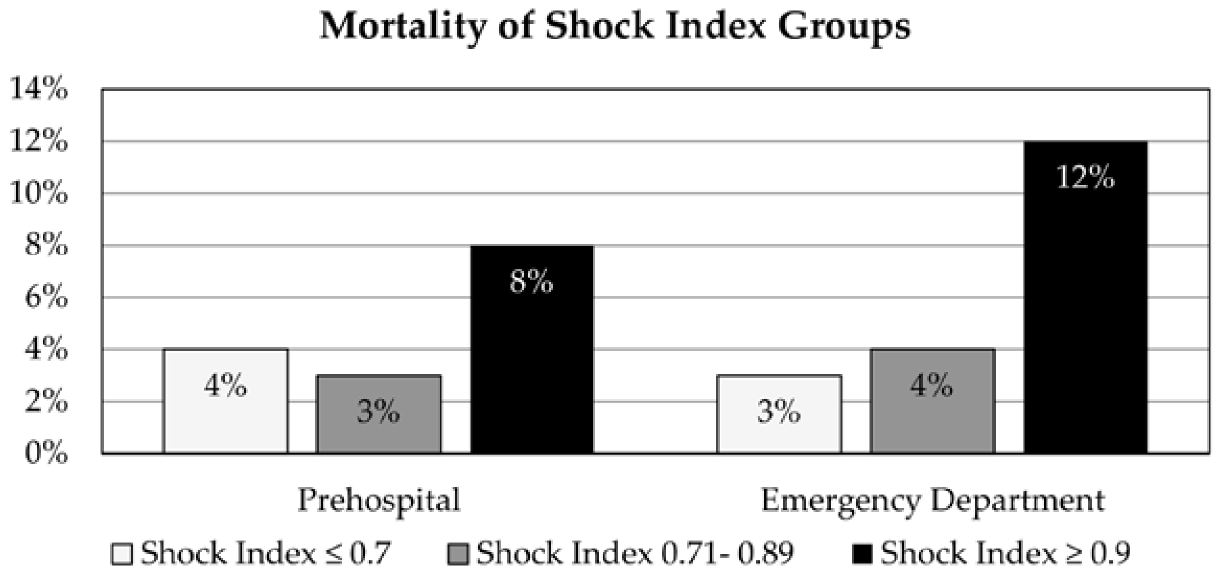

Figure 1: Mortality rates between shock index levels prehospital and emergency department.

total ICU days showed a small increase as the SI increased ($r(352) = 0.27$, $P < 0.01$), total ventilator days showed a small increase as the SI increased ($r(352) = 0.22$, $P = 0.02$), ISS showed a small increase as the SI increased ($r(352) = 0.26$, $P < 0.01$), packed red blood cells showed a small increase as the SI increased ($r(352) = 0.31$, $P < 0.01$), plasma ($r(352) = 0.19$, $P < 0.01$), platelets showed a small increase as the SI increased ($r(352) = 0.2$, $P < 0.01$), other blood substitute showed a small increase as the SI increased ($r(352) = 0.21$, $P < 0.01$) and total blood products showed a small increase as the SI increased ($r(352) = 0.32$, $P < 0.01$).

DISCUSSION

Trauma remains one of the leading causes of death in the United States. In Tennessee, the current trauma destination guidelines include Glascow Coma Score, systolic blood pressure, respiratory rate and anatomy of the injury. The SI is a quantifiable value proven to predict higher levels of mortality in trauma patients. Data from research on the SI have been primarily obtained from urban trauma centers. The goal of our study was to further validate its use in rural trauma centers, where the data has been scarce.

Access to trauma centers continues to be a major issue across the United Sates. In the 2010 United States Census, approximately 29.7 million Americans lived more than one hour away from a level 1 or 2 trauma center. With longer transport times, patients' vital signs are more likely to change. The need for a reliable index for rural trauma patients becomes grossly apparent.

Our study included 5,090 patients, all above the age of 18. As hypothesized, a lower SI (≤ 0.7) in both prehospital and ED patients had a higher rate of survival and a lower rate of need for transfusion. Patients with a SI ≥ 0.9 in both prehospital and ED patients had increased chances for mortality and need for transfusion. These findings correlated well with previous studies published about the SI in urban centers. The need for blood products in patients with elevated shock index is a significant finding as many rural non-trauma centers have limited access to blood products. A similar study using data from the Trauma Quality Improvement Program Database (TQIP) validated the correlation between a SI of > 1 and higher mortality, need for transfusion and resource utilization (Jehan et al, 2019). The study included 144,951 patients over two years from the TQIP. While our study included a smaller sample size, our data was noted to be similar to the data found at a sample of urban trauma centers.

As mentioned in the results section, we also noted positive correlations between a SI of ≥ 0.9 and multiple other outcome variables, including total ICU/hospital days, total ventilator days and specific blood products. The strongest positive correlation was between a SI of ≥ 0.9 and total amount of blood products (r=0.32). Again, the data from our rural center correlated well with data obtained from a level 1 trauma center in Jacksonville, Florida. This study found a significant positive correlation between a higher SI and average number of blood products, along with total hospital, ICU and ventilator days (King et al, 1996). The importance of SI and transfusion should be explored by EMS. A previous study evaluated the use of SI and pulse pressure as a reliable system for predicting patients in the prehospital setting that will require blood products (Plodr et al, 2023). A second study revealed patients with a SI > 1.0 had a higher probability of receiving a blood transfusion (Ortiz-Morales, 2020). These studies, coupled with our data, further validate the need to monitor SI in the prehospital setting to determine patients who are likely to require blood products.

Since the finalization and analysis of our data, we have implemented the use of the SI in our own trauma activation criteria. To facilitate ease of use, our criteria states that a heart rate greater than systolic blood pressure automatically meets highest priority (SI of >1.0). The American College of Surgeons also has recently implemented the SI in their "National Guidelines for the Field Triage of Injured Patients". Patients whose heat rate is greater than systolic blood pressure meet "red criteria", designating them at the highest risk for serious injury (American College of Surgeons, 2021).

LIMITATIONS

Some limitations of our study were data collection in the prehospital setting. We did not evaluate or take into account prehospital interventions done buy EMS such as the differences in manual versus mechanical blood pressures, administration of prehospital IV fluid, comorbidity factors, types of injuries, or an in-depth analysis of age. These may contribute to the decrease in SI values enroute to the ED. We also did not observe comparisons between patients that received advanced versus basic life support. A future direction may involve evaluation of such data to bring further insight to the SI as a predictive value.

Despite efforts to establish accurate documentation in our system, the possibility of error when documenting heart rate and blood pressure will always exist. It is possible data points were inaccurately or never recorded. Finally, this is a single institutional study and does not represent the entire rural population.

CONCLUSIONS

The shock index continues to be a reliable predictive value in trauma patients for morbidity and mortality. A SI of ≥ 0.9 in both the prehospital and emergency department settings had greater need for transfusion and higher mortality rates. There continues to be a need for further education of emergency medical services regarding the utility of the SI, as this is not a part of standard EMS training. With our data and results coming from a rural area and showing similar findings to urban areas, we continue to recommend its usage in both urban and rural trauma centers.

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RESEARCH REPORT

ASSESSING PROVIDER UNDERSTANDING OF INTERFACILITY EMERGENCY MEDICAL SERVICES TRANSFERS

Nancy Glober, MD*[1]; Thomas Lardaro, MD, MPH[1]; Michael Supples, MD, MPH[2]; Mark Liao, MD[1]; Julia Vaizer, MD[1]; Gregory Faris, MD, MPH[1]; Paige Ostahowski, MD[1]; Daniel O'Donnell, MD[1]; Christopher Kao, MD[1]

Author Affiliations: 1. Department of Emergency Medicine, Indiana University School of Medicine, Indianapolis, Indiana, USA; 2. Department of Emergency Medicine, Wake Forest, Wake Forest, North Carolina, USA

**Corresponding Author*: nglober@iu.edu

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ABSTRACT

Background: Interfacility transfers between hospitals are integral to regional healthcare systems. The decisions sending clinicians make regarding emergency medical services (EMS) transport team capability and transport modality (ground versus air) can dramatically impact patient care, emergency departments' workflow, hospital length of stay, and EMS resource availability. More research is needed to assess emergency medicine clinicians' understanding of interfacility transport.

Methods: We developed six patient scenarios to test knowledge of EMS transport team capabilities and mode of interfacility transfer. Seven board-certified EMS physicians determined the optimal answer to each patient scenario. We distributed a survey with the scenarios to regional healthcare partners via a database of persons who utilize or interface with interfacility transport services. We collected answers to the patient scenarios and clinician characteristics (primary practice site, sex, age, specialty, years since graduation, clinician degree, respondent-reported EMS training received). Descriptive statistics were performed, and Fisher's exact tests described differences in correct answers as they varied by specialty (emergency medicine or other specialty), clinician type (physician or advanced practice provider), and reported training in EMS level of care.

Results: Seventy-six emergency medicine clinicians responded (5%), including 68 physicians and eight advanced practice providers. The mean total score on the case scenarios was 69%, with scores ranging from 33% to 100%. The mean scores on questions testing transport team capability and transport modality were 67% and 70%, respectively. No significant difference was found in test scores between emergency medicine and other specialties ($p=0.718$), clinician level of training ($p=0.644$), or respondent-reported training in EMS transport capabilities ($p=0.943$).

Conclusion: Variability exists in clinicians' knowledge of interfacility transport throughout the region studied. Regional healthcare systems could benefit from clinician education on interfacility transfer resources and capabilities.

INTRODUCTION

Interfacility transfer of patients by emergency medical services (EMS) between hospitals is an integral component of healthcare, which relies on the interconnectivity of a regionalized system. Emergency medicine clinicians' decisions regarding transport team capabilities and transport modality (ground versus air) can dramatically affect patient care, emergency departments' workflow, hospital length of stay, and systemwide interfacility resource availability. Despite this, a statement from the Interfacility Transfer Workgroup and the Emergency Medical Services National Research Agenda declared that a lack of scientific knowledge "about optimal interhospital transfers" has confused clinicians and left them floundering to provide the best care without the guidance of good science (NHTS, 2006). In this setting, it is important for clinicians to be educated in local resource availability and capabilities to make informed decisions when transferring patients.

The impact of interfacility transfer to patients can be substantial. Transfer includes potentially significant cost and travel away from families and social support networks. (Allen, 2014, p. 346; Britton, 2017, p. 565; Coleman, 2003, p. 549; Coleman, 2003, p. 556; Enderlin, 2013, p. 47, Hirschman, 2018, p. 58; Marengoni, 2011, p. 430; Naylor, 2011, p. 746; Dwyer, 2014, p. 759). Furthermore, the needs of patients requiring interfacility transfer vary dramatically; some patients have emergent, time-critical diagnoses whereas some are clinically stable without urgent needs. Selection of appropriate resources by sending clinicians is important to optimize systemwide EMS utilization and ensure availability of the necessary level of care and mode of transport for each patient.

Despite the need, there is little standardization or education on local resource availability and appropriate utilization for interfacility transfer. Additionally, there is a paucity of research to assess the understanding of interfacility transport by emergency department clinicians. The aim of this study was to test sending clinicians' knowledge regarding interfacility transfers within a regional healthcare system in the midwestern United States via a series of case scenarios.

METHODS

We developed seven clinical cases with multiple choice answers specifically to test knowledge around the appropriate level of care for interfacility transfer (critical care, advanced life support, or basic life support) and appropriate mode of transport (air versus ground) (Supplemental Figure 1).

The Delphi technique was utilized to refine the patient scenarios and select the correct answer based on local protocols, policies, and resources (Dalkey, 1963, p. 458; Goodman, 1987, p. 729). A regional group of seven faculty emergency medicine physicians, all dual board-certified in Emergency Medicine or (in one case) Pediatric Emergency Medicine and EMS, participated in refining the questions and answers. This group included medical directors for six distinct EMS agencies that provide prehospital care and interfacility transports throughout Indiana. The cases were reviewed, discussed, and refined over the course of three separate meetings and tested on five outside clinicians. The case scenarios were entered into a REDCap (Nashville, TN) form and distributed to 1,236 recipients of a marketing customer distribution list of the largest interfacility transport entity in the region from various hospital systems and public safety agencies. The distribution also went to up to 16 hospital staff emergency medicine physicians (250 clinicians) at the discretion of each site's emergency medicine medical director, who received the survey instrument with a request to distribute it to their respective teams.

We collected case answers and clinician characteristics (primary practice site, sex, age, specialty, years since graduation from training, clinician degree, and any EMS training received).

Descriptive statistics were performed in Prism GraphPad (San Diego, CA). We performed Fisher's exact tests to describe the differences in ability to correctly answer the case scenario questions as they varied by specialty (emergency medicine or other specialty), clinician type (physician or advance practice provider), and any training in EMS transport resource capabilities as reported by the respondent.

This study was approved by the Institutional Review Board #13707.

RESULTS

Seventy-six emergency medicine clinicians responded, including 68 physicians and eight advanced practice providers. This represented a response rate of 5%. Respondents listed 20 different emergency departments throughout Indiana as their primary practice sites. Most respondents (42, 55.3%) were male, and the median respondent was 41 years (interquartile range 36 - 50). Most clinicians (69, 90.8%) identified emergency medicine as their specialty; three were EMS board-certified. Slightly more than half (42, 55.2%) indicated they received some training in selecting interfacility transfer team level of care (Table 1).

	Number of Respondents (n=76)
Gender	
Male	42 (55.3%)
Female	29 (38.2%
Prefer not to identify gender	5 (6.6%)
Age	
Median years (IQR)	41 (36-50)
Years from residency completion	
< 5 years	15 (19.7%)
5-10 years	19 (25.0%)
11-15 years	14 (18.4%)
>15 years	27 (35.5%)
Physician or non-physician	
Physician	68 (89.5%)
Advanced Practice Provider	8 (10.5%)
Clinician Specialty	
Emergency Medicine	69 (90.8%)
Family Medicine	5 (6.6%)
Internal Medicine	2 (2.6%)
Respondent-reported Training in Interfacility Transfer Selection	
Yes	42 (55.2%)
No	34 (44.7%)

Table 1. Characteristics and training level of survey respondents.

	Number of Respondents (n=76)
Responsible for level of care selection	
Physicians	67 (88.2%)
Advanced practice providers	2 (2.6%)
Transfer center	2 (2.6%)
Unknown by respondent	5 (6.6%)

Table 2. Clinician impression of who in the emergency department is primarily responsible for the level of care during interfacility transfer.

Most clinicians (67, 88.2%) reported that physicians were primarily responsible for determining the level of care for interfacility transfer (Table 2).

No significant differences were found between physicians and advanced practice providers or between clinicians whose primary specialty was emergency medicine and those whose primary specialty was not emergency medicine in correctly answering the questions (Supplemental Tables 1 and 2). Total correct answers (number and percent) included answers that agreed with the subject matter experts' consensus and are included in the survey shown in Supplemental Figure 1. Training in EMS transport resource capabilities reported by the respondent did not correlate with a significant difference in correct answers for the level of care questions (p=0.231) or the transport modality questions (p=0.182) (Table 3).

DISCUSSION

This study highlights the need for improved clinician training in appropriately selecting interfacility transfer resources. Although EMS systems vary considerably from one agency to the next, the regionalization of healthcare means that clinicians at sending facilities should have a basic understanding of the resources available in their geographic region for interhospital transfer and the capabilities of prehospital clinicians at different levels of care. Interhospital transfer resources are limited; patients requiring interhospital transfer may have time-critical emergencies. Thus, to appropriately utilize available resources and provide optimal care to each patient, it is imperative that sending clinicians have an up-to-date, comprehensive understanding of the appropriate modality for transport, and capabilities of different clinician levels.

Question Topic	Total (n=76)	With EMS Training (n=42)	Without EMS Training (n=34)	p-value
Level of Care				
Case 1	50 (65.8%)	25 (59.5%)	25 (73.5%)	0.232
Case 2	43 (56.6%)	25 (59.5%)	18 (52.9%)	0.644
Case 3	47 (61.8%)	26 (61.9%)	21 (61.8%)	0.999
Case 4	64 (84.2%)	35 (83.3%)	29 (85.3%)	0.999
Case 5	34 (44.7%)	17 (40.5%)	17 (50.0%)	0.489
Case 6	68 (89.5%)	35 (83.3%)	33 (97.1%)	0.068
Total Correct	**306 (67.1%)**	**163 (64.7%)**	**143 (70.1%)**	**0.231**
Type of Transport				
Case 1	26 (34.2%)	17 (40.5%)	9 (26.5%)	0.232
Case 2	64 (84.2%)	36 (85.7%)	28 (82.4%)	0.758
Case 3	54 (71.1%)	30 (71.4%)	24 (70.6%)	0.999
Case 4	64 (84.2%)	36 (85.7%)	28 (82.4%)	0.758
Case 5	67 (88.2%)	38 (90.5%)	29 (85.3%)	0.503
Case 6	44 (57.9%)	26 (61.9%)	18 (52.9%)	0.488
Total Correct	**319 (70.0%)**	**183 (72.6%)**	**136 (66.7%)**	**0.182**
Total Score	**625 (68.5%)**	**346 (68.7%)**	**279 (68.4%)**	**0.943**

Table 3. Clinician responses as they varied with or without EMS training.

Question Topic	Total (n=76)	Physician (n=68)	Advanced Practice Provider (n=8)	p-value
Level of Care				
Case 1	50 (65.8%)	46 (67.7%)	4 (50.0%)	0.434
Case 2	43 (56.6%)	38 (55.9%)	5 (62.5%)	0.999
Case 3	47 (61.8%)	40 (58.8%)	7 (87.5%)	0.14
Case 4	64 (84.2%)	57 (83.8%)	7 (87.5%)	0.999
Case 5	34 (44.7%)	30 (44.1%)	4 (50.0%)	0.999
Case 6	68 (89.5%)	61 (89.7%)	7 (87.5%)	0.999
Total Correct	**306 (67.1%)**	**272 (68.7%)**	**34 (70.8%)**	**0.628**
Type of Transport				
Case 1	26 (34.2%)	25 (36.8%)	1 (12.5%)	0.251
Case 2	64 (84.2%)	57 (83.8%)	7 (87.5%)	0.999
Case 3	54 (71.1%)	46 (67.7%)	8 (100.0%)	0.096
Case 4	64 (84.2%)	58 (85.3%)	6 (75.0%)	0.605
Case 5	67 (88.2%)	59 (86.8%)	8 (100.0%)	0.587
Case 6	44 (57.9%)	40 (58.8%)	4 (50.0%)	0.714
Total Correct	**319 (70.0%)**	**285 (69.9%)**	**34 (70.8%)**	**0.999**
Total Score	**625 (68.5%)**	**557 (68.3%)**	**68 (70.8%)**	**0.644**

Table 4. Physician versus advanced practice provider responses to questions.

Question Topic	Total (n=76)	Emergency Medicine (n=69)	Non-Emergency Medicine (n=7)	p-value
Level of Care				
Case 1	50 (65.8%)	45 (65.2%)	5 (55.3%)	0.999
Case 2	43 (56.6%)	40 (58.0%)	3 (38.2%)	0.46
Case 3	47 (61.8%)	43 (62.3%)	4 (57.1%)	0.999
Case 4	64 (84.2%)	59 (85.5%)	5 (55.3%)	0.304
Case 5	34 (44.7%)	31 (44.9%)	3 (38.2%)	0.999
Case 6	68 (89.5%)	62 (89.9%)	6 (85.7%)	0.557
Total Correct	**306 (67.1%)**	**280 (67.6%)**	**26 (61.9%)**	**0.492**
Type of Transport				
Case 1	26 (34.2%)	23 (33.3%)	3 (38.2%)	0.685
Case 2	64 (84.2%)	57 (82.6%)	7 (100.0%)	0.589
Case 3	54 (71.1%)	50 (72.5%)	4 (57.1%)	0.406
Case 4	64 (84.2%)	57 (82.6%)	7 (100.0%)	0.589
Case 5	67 (88.2%)	60 (87.0%)	7 (100.0%)	0.589
Case 6	44 (57.9%)	42 (60.9%)	2 (28.6%)	0.124
Total Correct	**319 (70.0%)**	**289 (69.8%)**	**30 (71.4%)**	**0.999**
Total Score	**625 (68.5%)**	**569 (68.7%)**	**56 (66.7%)**	**0.712**

Table 5. Emergency medicine versus other specialty clinician responses to questions.

Only about half (55.2%) of clinicians reported any training in EMS level of care, which was surprising because experience in EMS is required training by the American College of Graduate Medical Education for emergency medicine residents (ACGME, 2022). It is possible that clinicians received only limited training that was not recalled or received training that did not include EMS transport team capabilities. Given that resources and capabilities in EMS can change, local EMS agencies and their partnering hospitals may consider standardized training and updates for clinicians utilizing transport resources.

Clinicians who reported training on EMS level of care did not perform better on the six case scenarios or the level of care questions. This raises the possibility that the EMS training offered could have effectively educated clinicians, specifically in EMS transport team capabilities. It is also possible that training was remote, without regular refresher training, or the EMS capabilities changed over time. Regardless, a better global understanding of EMS transport resource capabilities can likely improve stewardship of such resources.

LIMITATIONS

The overall low respondent rate limits this study. Although we attempted to develop and test the survey through a generally accepted methodology, any survey is open to interpretation. Furthermore, the questions and answers selected in the survey are applicable to the region in question and may not be externally valid. Real-world decisions around interfacility transfer from one hospital to another are complex, with additional factors contributing to the decision of level of care or transport type. Such factors could include the existing regional transport capabilities and the distance between the sending and receiving facilities. It is possible that clinicians may not always be the individuals requesting transport resources and that individuals such as unit secretaries and other stakeholders should be included in future investigations since they are typically involved in requests for transport resources at the behest of clinicians in some localities such as the one studied here.

CONCLUSION

This study provides valuable insight to leaders in EMS and emergency departments who work with clinicians who regularly transfer patients. The study results suggest that those clinicians have a limited understanding of the interfacility transfer system. Further study should explore details of EMS training already offered, regional variation of that training, and the optimal delivery methods to improve clinicians' baseline knowledge in interfacility transfer topics.

SUPPLEMENTAL MATERIAL - SURVEY CONTENT

Surveys with clinical scenarios were distributed to test knowedge of the appropriate level of care and transport mode for patients undergoing interfacility transfer. Correct scenario answers are highlighted.

What site do you work at?

Who in your department determines level of care for transfer?
A. *I don't know*
B. *Physician*
C. *Nursing staff*
D. *Transfer center*
E. *Unit secretary*
F. *APP*

Age:

Gender
A. *Male*
B. *Female*
C. *Other*
D. *Prefer not to identify*

Board certification – EM/ subspecialty/Advance Practice Provider?

Year graduated from residency:

Did you receive any training in EMS level of care?
A. *Yes*
B. *No*

EMS Transport Survey Scenarios

Case 1*: 72-year-old female with history of HTN, DM presents with left sided weakness and facial droop. CT imaging is concerning for large MCA stroke. Last known well was 3 hours ago. Patient is not a tPA candidate but is a thrombectomy candidate. Patient is hemodynamically stable without airway compromise. Your hospital is 60 miles from the nearest comprehensive stroke center. Your impression is that the patient has a time-dependent emergency requiring a higher level of care but will require minimal if any interventions while in transit.*

What is the lowest level of care appropriate?
a) *Critical care*
b) *Advanced Life Support (ALS)*
c) *Basic Life Support (BLS)*

Please select the most appropriate mode of transport, assuming all resources are available and there are optimal traffic and weather conditions.
a) *Rotor*
b) *Ground*
c) *Most readily available*

Case 2*: A 3-year-old male with no significant PMH presents after swallowing a foreign body. You note a button battery in the airway on the chest x-ray. The patient has intermittent stridor, but otherwise the patient is in no acute distress. You are 15 miles from a Children's Hospital. Please select the most appropriate transport. You anticipate that the patient may possibly, but not necessarily, require advanced airway maneuvers during transit in the event of acute decompensation.*

Please select the most appropriate level of care
a) Critical care transport
b) ALS
c) BLS
d) Transport resource (ALS or critical care transport) with the earliest available ETA at the destination facility

Please select the most appropriate mode of transport, assuming all resources are available and there are optimal traffic and weather conditions.
a) Rotor
b) Ground

Case 3: *A 25-year-old male presents as major trauma alert. On CT imaging you note a grade 2 splenic laceration and multiple fractures of his extremities. He otherwise has no other injuries and is hemodynamically stable. There is no respiratory distress. You believe that the patient is unlikely to decompensate, but he does require a higher level of care for admission for his traumatic injuries. After discussion with the receiving trauma surgeon, you do not believe this is time critical. You are 60 miles from the nearest level one trauma center.*

Please select the most appropriate level of care.
a) Critical care transport
b) ALS
c) BLS
d) Transport resource (ALS or critical care transport) with the earliest available ETA at the destination facility

Please select the most appropriate mode of transport, assuming all resources are available and there are optimal traffic and weather conditions.
a) Rotor
b) Ground
c) Most readily available with the earliest available ETA at the destination facility

Case 4: *A 68-year-old female with PMH for Factor V Leiden presents with shortness of breath. On CT imaging, she is noted to have a PE without right heart strain. Her vital signs are HR: 110, RR 22, O2 Sat: 94 on 2L nasal cannula. She is on a heparin drip that does not require any titration during transit. She requests transfer for admission as her specialists are in Indianapolis. You are 60 miles from the receiving hospital.*

Please select the most appropriate level of care.
a) Critical care transport
b) ALS
c) BLS

Please select the most appropriate mode of transport, assuming all resources are available and there are optimal traffic and weather conditions.
a) Rotor
b) Ground
c) Most readily available with the earliest available ETA at the destination facility

Case 5*: A 78-year-old male with PMH of CHF, DM, HTN, presents with fever, and flank pain. The patient is hypotensive and is eventually started on low dose norepinephrine with improvement. The patient has maintained a Mean Arterial Pressure of 65 without norepinephrine titration for an hour. The patient otherwise is in no distress, AAOx4. Your work-up is revealing for an infected nephrolithiasis and antibiotics are given. You do not have Urology available and need to transport for definitive care at a tertiary care hospital, which is 30 minutes away for overnight observation with possible urological intervention in the next 24 hours.*

Please select the most appropriate level of care.

a) Critical care transport
b) ALS
c) BLS
d) Transport resource (ALS or critical care transport) with the earliest available ETA at the destination facility

Please select the most appropriate mode of transport, assuming all resources are available and there are optimal traffic and weather conditions.

a) Rotor
b) Ground
c) Most readily available with the earliest available ETA at the destination facility

Case 6*: A 65-year-old septic patient who has received appropriate antibiotics and fluid resuscitation is now requiring a second pressor to maintain hemodynamic stability and is intubated with ARDS. The patient is being transferred 30 miles for ICU resources not available at the sending facility.*

Please select the most appropriate level of care.

a) Critical care transport
b) ALS
c) BLS
d) Transport resource (ALS or critical care transport) with the earliest available ETA at the destination facility

Please select the most appropriate mode of transport.

a) Rotor
b) Ground
c) Most readily available with the earliest available ETA at the destination facility

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RESEARCH REPORT

INJURIES ASSOCIATED WITH PREHOSPITAL CPR PROVIDED BY PROFESSIONALS AND NON-PROFESSIONALS IN BANGKOK EMS

Chakrapong Victor, MD*[1,2] and Nitikorn Poriswanish, MD, PhD[1]

Author Affiliations: 1. Department of Forensic Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand; 2. Krabi Hospital, Ministry of Public Health, Krabi, Thailand.

**Corresponding Author*: nitikorn.por@mahidol.ac.th

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ABSTRACT

Background: This study describes adverse outcomes from cardiopulmonary resuscitation (CPR) performed during out-of-hospital cardiac arrest by trained first responders and professional practitioners by exploring types of injuries and analyzing potential contributing factors.

Methods: Forensic autopsy data from a single center covering almost half of Bangkok, Thailand and its outskirts were retrospectively collected and analyzed from October 2020 to January 2021. The data were divided into two groups: trained first responders and professional practitioners. Thoraco-abdominal injuries to soft tissue, bone, and internal viscera were recorded. Factors including age, BMI, sternal length, and chest circumferencewere categorized in each injury and statistically compared.

Results: 139 cases reported as OHCA with the exclusion of thoraco-abdominal injuries were recruited. The most commonly found CPR injuries were chest wall fractures, especially those of ribs (65.7%). Bilateral anterior rib fractures were more common than unilateral. Age was found to be the only significant associated factor with rib fractures. Other observed injuries were sternal fractures, lung contusions and lacerations, epicardial and subendocardial hemorrhages, cardiac contusions, liver lacerations, and pancreatic and splenic hemorrhages. No statistical difference between injuries generated by trained first responders and professional practitioners is found.

Conclusion: This study may provide useful information for clinicians and forensic physicians to be aware of and investigate for potential injuries and complications from CPR.

BACKGROUND

Out-of-hospital cardiac arrest (OHCA) patients may receive initial CPR from bystanders, trained first responders, or professional practitioners, resulting in different outcomes owing to expertise and experiences (Anderson et al., 2011; Talikowska et al., 2020). In Thailand, trained first responders are volunteers who pass a short-course consisting of a few days of training. Professional pratitioners are physicians, registered nurses, or paramedics who receive advanced cardiac or traumatic life support (ACLS or ATLS) courses. OHCA patients are usually resuscitated by trained first responders, professional practitioners, or sometimes by automated devices, depending on EMS service availability in each area.

When patients survive to hospital admission, CPR injuries become issues of significant concern. Prior studies have shown a number of thoraco-abdominal injuries, including chest-wall fractures and intrathoracic and intra-abdominal visceral injuries (Boland et al., 2015; Deliliga et al., 2019; Girotti et al., 2022). These injuries not only add to patient suffering but also contribute to prolonged hospitalization.

This study explored and compared CPR-related injuries generated by trained first responders versus professional practitioners during out-of-hospital resuscitation attempts. The study also searched for factors significantly associated with such injuries.

METHODS

The data was retrospectively obtained via forensic autopsy reports and pictures, which were performed from October 2020 to January 2021 at a single center that is responsible fo medico-legal investigations of death for roughly half of Bangkok. The Institutional Review Board approved the study. The cardiac arrest cases recruited into the study must have received only manual chest compression methods. Those who received CPR by both kinds of practitioners or developed decomposition or contained antecedent thoraco-abdominal injuries indistinguishable from CPR were excluded from the study.

The total cases were subsequently divided based on the CPR performer into TFR for those who received manual CPR exclusively by trained first responders and PP for those who received manual CPR only by professional practitioners. Injuries of the chest wall, including skin, subcutaneous tissue, anterior mediastinum, sternal, and rib fractures, were recorded in association with intrathoracic and intra-abdominal injuries. Data were analyzed for the total group and each subgroup based on sex, age range, body mass index (BMI), sternal length (SL), and chest circumference (CC). Age was categorized in decades except for both extreme groups; therefore, the subgroups were ≤ 20, > 20-30, > 30-40, > 40-50, > 50-60, and ≥ 60 years. BMI was classified into five subgroups according to WHO (2004) for the Asian population (WHO Expert Consultation, 2004) that consisted of BMI ≤ 18.5, 18.5-22.9, 23.0-24.9, 25.0-29.9, and ≥ 30. SL and CC in centimeters were categorized based on percentile ranking of the dataset that principally consisted of ≤ P10, > P10-P25, > P25-P50, > P50-P75, > P75-P90, and ≥ P90 subgroups.

Locations of rib fracture were defined as anterior, ranging from the midline to anterior axillary line; lateral, ranging from anterior to posterior axillary lines; and posterior, ranging from posterior axillary line onwards.

Descriptive statistics and graph plotting were performed by Microsoft Excel 2019, while correlation analysis was done by IBM SPSS v.20. Statistical comparison was analyzed by Fisher s exact or Chi-square test via the online platform at https://astatsa.com/FisherTest/. Binary logistic regression analysis was used for determining significance.

An association factor was also calculated online at https://stats.blue/Stats_Suite/logistic_regression_calculator.html. Statistical significance was considered when $p \leq 0.05$.

RESULTS

A total of one hundred thirty-nine cases met the criteria and were recruited. The distribution of cases for the total TFR and PP groups with regard to sex, age, and BMI is presented in Tables 1 and 2. The number of cases in the ≤ 20 group is much lower than the others because it is concordant with the mortality rate of forensic cases.

CPR injuries were found in 85 cases (61.2%), of which the most significant number were rib fractures (55 cases, 64.7%), followed by sternal fractures (27 cases, 31.8%), intrathoracic (19 cases, 22.4%), intra-abdominal (8 cases, 9.4%) visceral injuries, and clavicular fracture (1 case, 1.2%). Lung and heart injuries were found in 7 and 12 cases, respectively, while intra-abdominal organs, i.e., liver and pancreas, were found in 8 and 1 cases, respectively. No splenic injury was observed. All of the lung injuries were contusions, whereas heart injuries were epicardial (10/12 cases) and subendocardial (2/12 cases) hemorrhage. Hepatic injuries were lacerations and contusions, while that of the pancreas was peripancreatic hemorrhage. Only a single injury of intrathoracic viscera was found, while those of intra-abdominal viscera contained a combined injury in one case.

	Age (years)					
	≤20	>20-30	>30-40	>40-50	>50-60	>60
Total (n=139, 100%)						
m (n=105, 75.5%)	n=6 (5.7%)	n=11 (10.5%)	n=28 (26.7%)	n=19 (18.1%)	n=23 (21.9%)	n=18 (17.1%)
f (n=34, 24.5%)	n=2 (5.9%)	n=1 (2.9%)	n=8 (23.5%)	n=6 (17.6%)	n=12 (35.3%)	n=5 (14.7%)
TFR (n=78, 56.1%)						
m (n=66, 84.6%)	n=3 (4.5%)	n=5 (7.6%)	n=18 (27.3%)	n=16 (24.2%)	n=13 (19.7%)	n=11 (16.7%)
f (n=12, 15.4%)	n=1 (8.3%)	n=0 (0.0%)	n=2 (16.7%)	n=3 (25.0%)	n=3 (25.0%)	n=3 (25.0%)
PP (n=66, 38.6%)						
m (n=39, 43.9)	n=3 (7.7%)	n=5 (12.8%)	n=10 (25.6%)	n=4 (10.3%)	n=10 (25.6%)	n=7 (17.9%)
f (n=22, 36.1)	n=1 (4.5%)	n=1 (4.5%)	n=5 (22.7%)	n=3 (13.6%)	n=10 (45.5%)	n=2 (9.1%)

Table 1. Distribution of cases in the age dataset. m = male, f = female.

	BMI				
	<18.5	18.5-22.9	23.0-24.9	25.0-29.9	>30
Total (n=139, 100%)					
m (n=105, 75.5%)	n=11 (10.5%)	n=29 (27.6%)	n=19 (18.1%)	n=35 (33.3%)	n=11 (10.5%)
f (n=34, 24.5%)	n=4 (11.8%)	n=10 (29.4%)	n=12 (35.3%)	n=3 (8.8%)	n=5 (14.7%)
TFR (n=78, 56.1%)					
m (n=66, 84.6%)	n=4 (6.1%)	n=20 (30.3%)	n=13 (19.7%)	n=21 (31.8%)	n=8 (12.1%)
f (n=12, 15.4%)	n=2 (16.7%)	n=3 (25.0%)	n=4 (33.3%)	n=1 (8.3%)	n=2 (16.7%)
PP (n=66, 38.6%)					
m (n=39, 43.9)	n=7 (17.9%)	n=10 (25.6%)	n=5 (12.8%)	n=14 (35.9%)	n=3 (7.7%)
f (n=22, 36.1)	n=2 (9.1%)	n=7 (31.8%)	n=8 (36.4%)	n=2 (9.1%)	n=3 (13.6%)

Table 2. Distribution of cases in the BMI dataset. m = male, f = female.

Of the rib fractures, 37 cases (68.5%) contained bilateral rib fractures, of which 35 cases (94.5%) were located at the anterior part of both sides. A few cases were found equally located at the lateral and posterior parts and were usually combined with those at the anterior part. Unilateral fractures were equally found on either side (9 cases per side). Similarly, anterior fractures were predominant (8/9 for both sides). Fractures commonly occurred in the first to eighth ribs.

The second most common injury was a sternal fracture, mostly found between the second to fifth intercostal spaces. Injuries of intrathoracic viscera, the third most common injury, occurred in the lungs and were of similar number as those in the heart (11 against 12 cases); both of them occurred separately.

Sites commonly found for liver lacerations were located at the right lobe and in the middle part. Peripancreatic hemorrhage was observed around its head.

The SL and CC subgroups were categorized by percentile, as described above. For SL subgroups, data were finally divided as ≤ 15, > 15-17, > 17-19, > 19-21, > 21-23, and ≥ 23 centimeters, while CC subgroups were divided as ≤ 74.9, > 74.9-79.8, > 79.8-87.0, > 87.0-93.0, > 93.0-99.0, and ≥ 99.0 in centimeters as well. Soft tissue injuries involving skin, subcutaneous, and anterior mediastinum were counted together for each age, BMI, SL, and CC subgroup in the total data, TFR, and PP. Bony fractures of the ribs and sternum and intrathoracic and intra-abdominal visceral injuries were also counted similarly. Multivariate binary logistic regression was performed to determine the significant contributing factor(s). Then, the contributing factor(s) were analyzed by Chi-square or Fisher s exact test to define a cut-off point.

Of the total data, only rib fracture showed a statistical significance by logistic regression analysis among different ages ($p < 0.01$). By Chi-square analysis, the age of 30 shows a significant cut-off point ($p < 0.01$). Summary details are in Table 3 and Figure 1.

Independent Variable	Odds Ratio	95% Confidence Interval	*p*
Age	1.05	(1.02-1.08)	<0.01
Gender	1.01	(0.41-2.45)	0.99
BMI	1.07	(0.98-1.18)	0.13
SL	0.96	(0.86-1.08)	0.52
CC	1.00	(0.95-1.06)	0.92

Table 3. Binary logistic regression results assigning rib fracture as a dependent variable.

In TFR, soft tissue injuries were statistically different among age groups ($p = 0.023$), while bony injuries involving rib and sternal fractures were statistically different among SL groups ($p < 0.01$). In PP, soft tissue injuries and rib fractures were both statistically different among age groups ($p = 0.04$ and < 0.01, respectively), while only bony injuries were statistically different among BMI groups ($p = 0.02$).

Prevalence of rib fractures of the TFR was slightly less than those of the PP (27/78 or 34.6% against 26/61 or 42.6%); however, Chi-square or Fisher s exact test showed no significant difference between both groups with regards to the cut-off age. Spearman s rank correlation coefficient showed a significantly strong pairwise correlation of rib

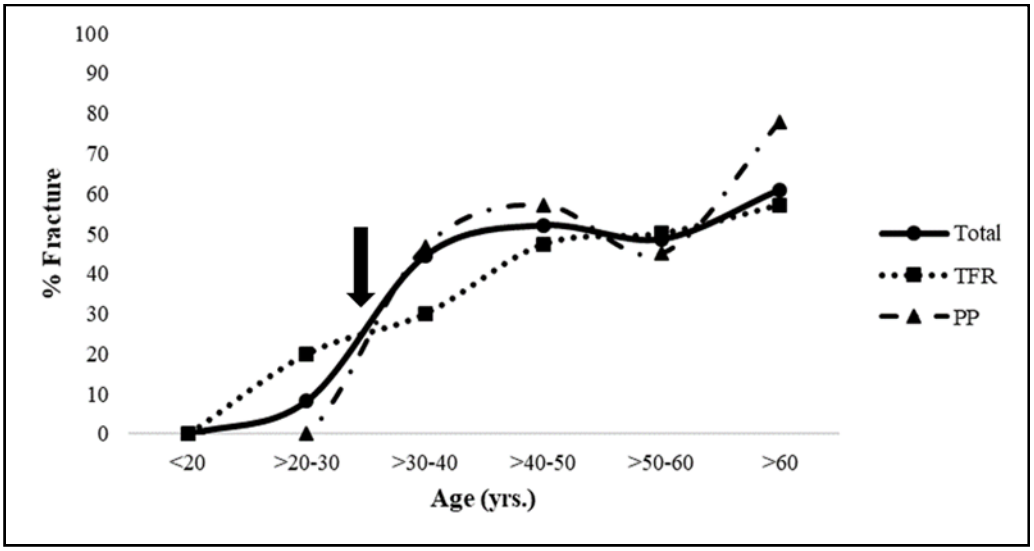

Figure 1. Percent of chest wall fractures. Fracture distribution by age shows the cut-off point at 30 years (black arrow).

fracture only by age. The correlation coefficient (rs) between the total group and TFR is 1.00 ($p < 0.01$), rs between the total group and PP is 0.81 ($p = 0.05$), and rs between TFR and PP is 0.81 ($p = 0.05$).

DISCUSSION

OHCA has been reported to generate CPR-related injuries in association with the duration of chest compression and survival (Boland et al., 2015; Takayama et al., 2018). Victims who fail to gain ROSC usually receive chest compression for more than 10-15 minutes, leading to an increased prevalence of chest injuries (Boland et al., 2015; Takayama et al., 2018). To access a greater possibility of detecting a wide variety of CPR-related injuries, this study examines autopsied cadavers, as previously reported (Deliliga et al., 2019; Girotti et al., 2022). Rib fractures are the most prevalent of complications found after CPR, similar to prior studies (Friberg et al., 2019; Karasek et al., 2021).

This study explores the significant factors associated with rib fractures and finds that older age, similar to those previously described (Takayama et al., 2018; Karasek et al., 2021; Moriguchi et al., 2021; Kralj et al., 2015), is a strong contributor. However, this study defines the cut-off point at the age of 30 to discriminate a statistically significant acceleration of prevalence (Figure 1).

The cut-off age in this study is in concordance with costal calcification staging previously reported (Patyal & Bhatia, 2022; Zhang et al., 2017), which may be one of the factors susceptible to cause fractures. This study cannot identify that BMI could be significantly associated with rib fractures; however, it could affect the performance of CPR in obese patients (Tellson et al., 2017).

This study also finds that bilateral rib fractures are more common than unilateral. The different results from the prior study (Kaldırım et al., 2016) might result from many conditions, such as the varied skills of CPR performers from person to person and from place to place (Anderson et al., 2011; Talikowska et al., 2020). However, this may help CPR training emphasize substantial points for trainees to reach the satisfying goals. In addition, soft tissue injuries of the chest wall are associated with age, but they are serious complications nonetheless. There is no statistical difference in the other factors, i.e., SL and CC, in association with injuries except for an association between bony fractures of the chest wall and SL only in the TFR group. This finding has yet to be observed further because our sample size is not large enough.

This study could be primarily summarized that there is no significant difference in rib fractures between CPR performance by trained first responders and professional practitioners even though professional practitioners generate a slightly higher incidence of rib fractures than trained first responders. This could be owing to higher CPR quality (Talikowska et al., 2020).

Despite lower incidence, internal visceral injuries are of more concern because they can potentially result in severe morbidities. In this study, lung lacerations, contusions, and liver lacerations are observed. However, most of the heart injuries are found to have very limited severities, which are hemorrhage in the epicardium and subendocardium. However, it is not clear whether subendocardial hemorrhage is directly caused by chest compression or by other factors, such as adrenaline administration during CPR (Charaschaisri et al., 2011). Sites of hepatic injuries are of interest for clinical and forensic aspects. This data may help CPR performers respond more quickly and effectively to life-threatening conditions in severe lacerations. It also guides forensic physicians to concern and distinguish CPR injuries from antecedent trauma. The pancreatic and splenic injuries found here are of less clinical significance because they do not involve organ parenchyma.

LIMITATIONS OF THIS STUDY

We are concerned that as automated CPR devices become more available, even in OHCA, the future direction should focus on the device's effectiveness and outcome, especially between different manipulating skills. Because of better rib recoil, it is of greater interest to have more infant CPR cases enrolled in future studies to investigate possible adverse outcomes.

CONCLUSION

This study describes a landscape of CPR-related injuries performed by personnel with different training backgrounds. Chest wall fractures are the most common complication, followed by intrathoracic and intra-abdominal injuries. Advanced age may significantly contribute to the incidence of rib fractures.

Professional practitioners generate little more incidence of fractures than trained first responders without statistical significance. Lung injuries are found to be severe and most common. Finally, the study also allows forensic physicians to distinguish between injuries caused by CPR and antecedent trauma.

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RESEARCH REPORT

NAVIGATING PARAMEDICS' SAFETY: UNRAVELING FACTORS IN EMERGENCY SERVICE VEHICLE INCIDENTS

Milad Delavary, MSc[1], Mathieu Tremblay, PhD[2], Martin Lavallière, PhD*[1]

Author Affiliations: 1. Department of Health Sciences, Laboratoire BioNR and Centre Intersectoriel en Santé Durable (CISD), Université du Québec à Chicoutimi, Chicoutimi, Québec, Canada; 2. Department of Health Sciences, Université du Québec à Rimouski, Rimouski, Québec, Canada.

**Corresponding Author*: martin_lavalliere@uqac.ca

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Keywords: ambulance crashes; drivers' characteristics, environment, emergency/non-emergency activities, work-related collisions, emergency medical services, paramedicine

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ABSTRACT

Problem: First responders form a critical cornerstone of public health, providing rapid and lifesaving medical assistance. However, paramedics are at a persistent elevated rate of collisions while in displacement compared to workers who drive vehicles of similar size and other professional drivers. This highlights a pressing concern that necessitates investigation.

Study Objective: This study is a retrospective study aimed to describe factors involved in paramedics' collisions.

Method: Spanning over 10 years of data (2010-2019) from a paramedic agency covering Montreal (Qc, Canada), links between the number of ambulance injuries and non-injury collisions and diverse characteristics like experience, sex, and age of paramedics, locations, and driving activities. The distribution of characteristics involved in the severity of collisions is presented with descriptive analysis. The evaluation of trends of monthly and yearly ambulance collisions is conducted along a logit model to examine the effect of such factors on the odds of collision severity.

Results: The results indicate that there is no decline in the trend of monthly ambulance collisions. However, calculating the yearly occurrence of non-injury collisions per 10 paramedics shows a statistically significant decline. Young paramedics with less ambulance driving experience are more involved in multiple collisions compared to their experienced colleagues. Furthermore, 62% of injury collisions happen when paramedics are responding to an emergency call, confirmed by a decrease in the odds of injury collisions (0.48) during non-emergency activities. Intersections and traffic lights are the riskiest locations regarding injury collisions (43.5%, and 51%, respectively). Collisions occurring at traffic lights can increase the odds of severity by nearly six times.

Conclusion: This study exemplifies that preventive policy regarding paramedics should focus on younger paramedics, paramedics less experienced in operating the vehicles, and risky locations, especially while on emergency calls. More oriented programs for paramedics are required to reduce the number of collisions.

INTRODUCTION

Center for Disease Control and Prevention (CDC) (United States of America) and the World Health Organization (WHO) (Switzerland) declared that traffic collisions lead to the death of approximately 1.35 million people per year (Centers for Disease

Control Prevention, 2005, 2020; World Health Organization, 2020) from which 33% of drivers involved in these collisions are mostly considered as work-related collisions (European Agency for Safety and Health at Work (EU-OSHA), 2019). More specifically, work-related collisions among emergency respondents have been identified as the leading cause of mortality (Fetto Law Group, 2018; Lavallière, 2015). As per the American Ambulance Association data, there are an estimated 10,000 or more ambulance-related collisions annually, with many of these resulting in injury or death (US Fire Administration, 2014). More specifically, compared to overall traffic collisions, ambulance vehicles are 1.7 times more likely to be involved in fatal collisions and 1.9 times more likely to be involved in injury collisions (Chiu et al., 2018).

Each year, emergency medical responders in the United States (US) experience an average of ten transportation-related fatalities (Maguire, 2015). Between 2006 and 2008, paramedics in the US encountered a traffic collision risk that was five times greater than the national average (Maguire, 2011). Additionally, their rate of occupational fatalities and injuries related to transportation collisions exceed the national average (Maguire, 2015; Maguire, 2013). Most of the fatalities in this sector result from collisions related to transportation. Traffic collisions accounted for 74% of paramedics' fatalities, with medical emergency responders driving in 69% of these incidents (Maguire et al., 2002). Furthermore, compared to other vehicles of similar size and weight, ambulances are more frequently involved in collisions (Ray & Kupas, 2005; Sanddal et al., 2008).

As per the usage of lights and sirens, there were 7.0 collisions without lights and sirens and 17.1 with lights and sirens per 100,000 trips in 2016 in the US (Watanabe, Patterson, Kempema, Magallanes, & Brown, 2019). Jarvis et al. (2021) found that the utilization of lights and sirens is linked to a rise in collisions and injuries among paramedics. Consequently, there is a pressing need for a structured approach to emergency medical responders in developing specific strategies for responding with lights and sirens. This is because only a small percentage (6.9%) of responses involving lights and sirens need potentially life-saving interventions.

Furthermore, 99,400 injuries and 65 mortalities were recorded between 2003 and 2007 for paramedics and emergency respondents from the Bureau of Labor Statistics (BLS) (USA), which shows a higher rate compared to other kinds of workers (Reichard, Marsh, & Moore, 2011). In Quebec (Canada), there are 1228 ambulance collisions (including 5 fatalities, 344 injuries, and 859 non-injury) covering from 2010 to 2020 (Soci t de l'assurance automobile du Qu bec, 2020). In Turkey, 81.4% of paramedics (n=733) declared being in at least one collision while on duty in an ambulance (GŸlen et al., 2016). In Poland, there were five deaths and 153 injured people from January 2008 to December 2012 (Galazkowski, Binkowska, & Samolinski, 2015). It is clear that work-related collisions happen worldwide and that they are of utmost importance to address.

Some studies reviewed the characteristics of paramedics involved in collisions. For example, it is found that males are involved more than females in ambulance collisions (almost 80% vs. 20%) (Chiu et al., 2018; Custalow & Gravitz, 2004) but there has been an increasing trend in the proportion of females recently (Galazkowski et al., 2015). Also, younger drivers (under 30 years old) are more involved in ambulance collisions (Galazkowski et al., 2015) and a study stated that ambulance drivers, the mean age of 32 years old, who are responsible for collisions had a previous history of multiple collisions in 71% of the cases (Custalow & Gravitz, 2004).

There is a wide range of literature looking at ambulance collisions' characteristics like environmental factors or time of collisions. For instance, the probability of a collision happening is higher during daytime hours (0800 to 1200) and evening hours (1600 to 2000) compared to other periods throughout the day (Chiu et al., 2018; Drucker, 2013; Lai, Chou, & Chang, 2018). Also, it is reported that almost 33 % of all ambulance collisions happened on Friday (Biggers, Zachariah, & Pepe, 1996). Looking at the location of collisions shows that there is a significant number of collisions happening at intersections; for instance, a T-bone mechanism or striking a vehicle with an angle is found to be a highly frequent type of ambulance crash (Custalow & Gravitz, 2004; Kahn, Pirrallo, & Kuhn, 2001). A descriptive study showed five fatal collisions (out of eight) and 463 non-fatal collisions (out of 707) happened at four-point intersections in Taiwan from January 2011 to October 2016 (Chiu et al., 2018). Collisions are statistically more prone to happen at intersections (67% vs. 26%) or at stop signs or signals (53% vs. 14%) in urban environments compared to rural areas (Ray and Kupas, 2007). There are other studies supporting the fact that four way or more intersections, and with traffic signals can increase the risk of ambulance injury and non-injury collisions (Drucker, 2013; Pirrallo & Swor, 1994; Ray & Kupas, 2005). As per weather conditions, a study shows that most collisions happened when the atmospheric conditions are clear (79.8%) and roadways are dry (67.9%), and only a few of them occurred on snow or ice (5.5%) (Pirrallo & Swor, 1994). Overall, one can appreciate that there are numerous factors influencing the implication of paramedics in collisions and their effects on the severity of collisions.

PURPOSE AND OBJECTIVES

The purpose of the current study is to descriptively and statistically analyze the key characteristics surrounding ambulance collisions in Montréal, Canada, that are not typically documented on a formal road safety data set. In this case, most collisions in locations like parking lots, hospitals, etc. were provided by Corporation d'urgences-santé (CUS) and not available in the Société de l'assurance automobile du Québec (SAAQ) data set. To our knowledge, this study is the first of its kind to focus on collision characteristics, with a specific focus on paramedics' factors such as age, experience, sex, and collision history in Canada.

The study received ethical approval from both the University of Quebec at Chicoutimi (2019-131, 602.545.04) and CUS scientific review committees, ensuring adherence to the necessary ethical standards for research.

METHODS

Data Collection

This research is based on paramedics' collision data collected in a corporation of a metropolitan city (Montréal, Canada) coming from CUS dataset including 4,577 non-injury and 136 injury collisions from January 2010 to December 2019. The CUS serves as the official public emergency medical service for Montréal and Laval islands in the province of Quebec (Canada), providing a comprehensive repository of detailed collision data involving medical emergency vehicles in these areas (CUS, 2023). Also, the SAAQ administers driver's licenses, vehicle registration, and Quebec's public automobile insurance plan, making it a comprehensive source of detailed collisions data for the province (SAAQ, 2020).

Statistical Analysis

This study aimed to understand the effect of contributing factors on the severity of ambulance collisions. To quantify the odds ratio of being involved in an injury collision for each unit increase in an explanatory variable, such as the age or experience of paramedics, a multivariable logit model was employed using Stata software (StataCorp LLC, USA). The interpretation of the odds ratio is the probability of an event happening when the factor of interest is present, divided by the probability of the event occurring when the factor is absent. To illustrate, consider the odds ratio for the involvement of drivers over 25 in crashes compared to those aged 25 and below. If the younger drivers are on the baseline and the odds ratio for the older drivers is 0.70, the older drivers are 30% less likely to be involved in a crash. The linear relationship between the explanatory variables and a binary response variable, including injury and non-injury collisions can be written in the following equation. Note that p-values less than 0.05 shows the effect of explanatory variables is statistically significant at the 95th percentile confidence limit.

$$\ell = \mathrm{Log}\frac{P}{1-P} = \beta_0 + \beta_i X_i$$

Equation 1 - Where ℓ is the log-odds, X_i is the independent variable, and β are the coefficients of the parameters of the model (Ma, Shao, Yue, & Ma, 2009).

One of the main steps is a variable selection to use in logit regression. This study used the variance inflation factor (VIF) to check multicollinearity. VIF values above 5 indicate severe multicollinearity. So, if none of the explanatory variables in our models have a VIF over 5, it is assumed that multicollinearity is not an issue in our model. The existence of collinearity between variables rejects the assumption of independence. So, in such models, it is possible to estimate the parameters despite the collinearity, but the standard error will be inflated and, make it impossible to understand the importance and impact of each variable (Dormann et al., 2013).

The next step is examining the performance of the model by using measures such as a Receiver Operating Characteristic (ROC) curve. This is a graph that shows the performance of a classification model at all response thresholds. This graph is produced by plotting the true positive rates (y-axis) with the false positive rates (x-axis) (Markham, 2014). The ROC curve is an important indicator for evaluating the overall performance of the logit regression, which generally shows whether the true positive rate is higher than the false-positive rates. Area Under Curve of ROC Curve (AUC-ROC) shows the relationship between sensitivity and specificity. The value of this number is used to describe the overall performance of a classification model in which values close to 1 represent an accurate classification and values less than 0.5 are considered not acceptable (Mujalli, López, & Garach, 2016; Provost & Domingos, 2000). Furthermore, the other measurements to assess the goodness of fit is Pseudo R2 and correctly classified (%) values which measure the number of actual positives and negatives which are correctly classified. This study chooses the best-fitted model based on the maximum Pseudo R2, the area under the ROC curve, and correctly classified (%) values.

Additionally, Shewhart's control charts help us figure out if the variation in data is normal or caused by specific circumstances (Nolan et al., 2016; Perla et al., 2011). There are two types of reasons for such variations: common causes that happen naturally over time, and special causes that are not part of a system and happen because of specific circumstances. Shewhart's chart has three lines including the central line and upper and lower control limit lines and points plotted on a graph. If the points are plotted outside of control limit lines, there is a sign of special causes of variation in data. Control limits are typically set at a certain number of standard deviations from the process mean or centerline.

To assess the trend and changes within the studied datasets, the Mann-Kendall and Wilcoxon rank sum tests were employed, respectively. The null hypothesis for Mann Kendal test is that there is no decreasing/increasing trend and the null hypothesis for the Wilcoxon rank sum test is true location shift is equal to zero.

RESULTS

Descriptive Analysis

We cross-referenced the CUS data presented in Table 1 with the collision dataset from the SAAQ for the corresponding time frame and geographical region. This table shows the percentage of overlap for the same data (injury or non-injury collisions) in different source databases including CUS and SAAQ. For instance, in 2019, only 6.83% of all non-injury collisions were matched in both CUS and SAAQ and 88.78 were only available in the CUS dataset. This is because SAAQ primarily records severe collisions that result in injuries or fatalities.

There were 2.11% injury and 5.41% non-injury cases (out of total collisions) matched for both sources during the period from January 2010 to December 2019. Of these, 90.27% of non-injury collisions are only available in CUS datasets which means these are minor collisions that were only recorded internally. Additionally, the SAAQ dataset includes 0.6% injury and 1.4% non-injury collisions that were not present in the CUS dataset. These collisions were incorporated into the CUS data to create a comprehensive dataset for this study.

Year	Injury Collisions			Non-Injury Collisions		
	Available in both CUS and SAAQ	Available only in CUS	Available only in SAAQ	Available in both CUS and SAAQ	Available only in CUS	Available only in SAAQ
2010	4.19	0.44	1.10	4.86	86.31	3.09
2011	3.22	0.00	1.61	4.63	88.13	2.41
2012	1.94	0.39	0.39	5.81	89.73	1.74
2013	1.59	0.2	0.00	5.17	92.05	0.99
2014	2.07	0.00	0.62	6.22	90.25	0.83
2015	0.88	0.44	0.22	4.16	93.44	0.88
2016	1.24	0.00	0.41	3.91	93.83	0.62
2017	1.79	0.22	0.67	6.71	89.49	1.12
2018	1.95	0.00	0.22	5.84	90.69	1.30
2019	2.2	0.24	0.73	6.83	88.78	1.22
Mean	**2.11**	**0.19**	**0.60**	**5.41**	**90.27**	**1.42**

Table 1. Similarity between CUS and SAAQ sources (in percentage).

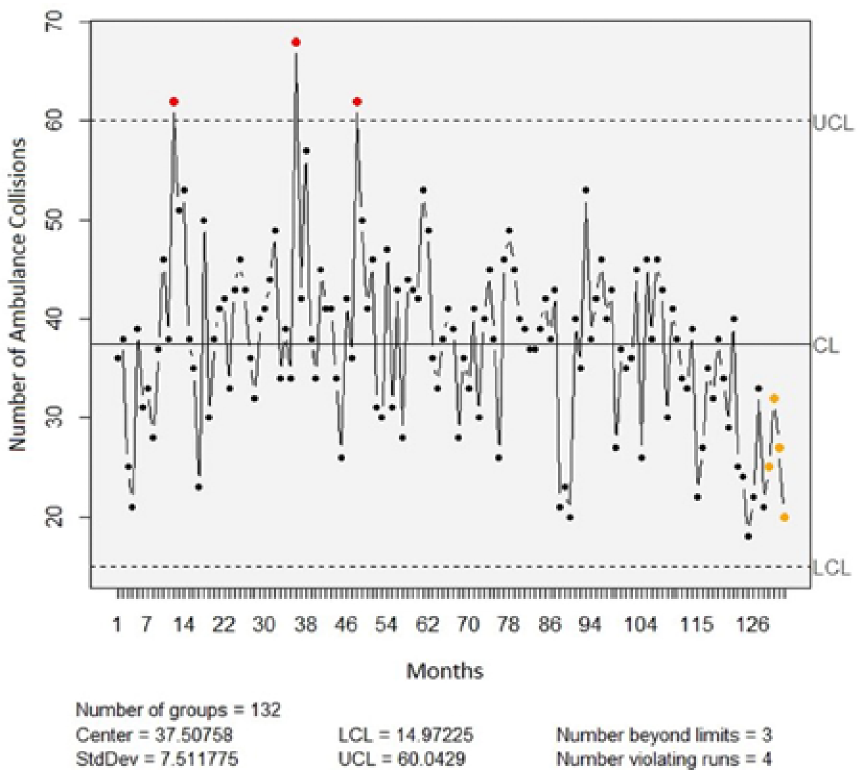

Figure 1. Shewhart Chart of Ambulance Monthly Collisions between January 2010 and December 2020 in Montreal, Quebec.

Figure 1 shows a Shewhart chart that tracks the monthly collisions involving ambulances from January 2010 to December 2020. The chart has a centerline at 37.5076, and there are lower and upper control limit lines, which are set at 14.9723 and 60.0429, respectively. Most of the data points on the chart cluster around the centerline, showing that the ambulance collisions are typically within a certain range. However, there are only three points that go beyond these control limits, indicating the possibility of outliers or special causes for these particular points. For analyzing the trend of ambulance monthly collisions visible in this Figure, the Mann Kendal test was also used. The result shows that no trend is found for this time series (p-value= 0.2746).

Also Figure 2 shows the incidence of yearly injury collisions per 10 paramedics and non-injury collisions per 10 paramedics covering from 2010 to 2019. The reason for presenting the incidence of injury collisions per 10 paramedics in Figure 2 is to aid visualization, as these types of collisions occur significantly less frequently than non-injury collisions. Although there is a significant drop (Wilcoxon rank test; p-value= 0.0495) after 2011 in the incidence of injury, there is no significant decrease in the overall trend (Mann Kendal test; p-value= 0.0736). Furthermore, there is a significant reduction trend (Mann Kendal test; p-value= 0.0123) for the incidence of non-injury collisions.

Distribution of injury and non-injury collisions during a week and along a day are shown in Figures 3 and 4. In this regard, the time-of-day variable was divided into 12 periods of 2 hours bins. The percentage of injury collisions from 20:00 to 21:59 and non-injury collisions from 16:00 to 17:59 are higher than other periods with 16.67% and 13.60%, respectively. And paramedic drivers were less involved in injury collisions (0.93%), and non-injury collisions (2.48%) from 4:00 a.m. to 5:59 a.m. Furthermore, the

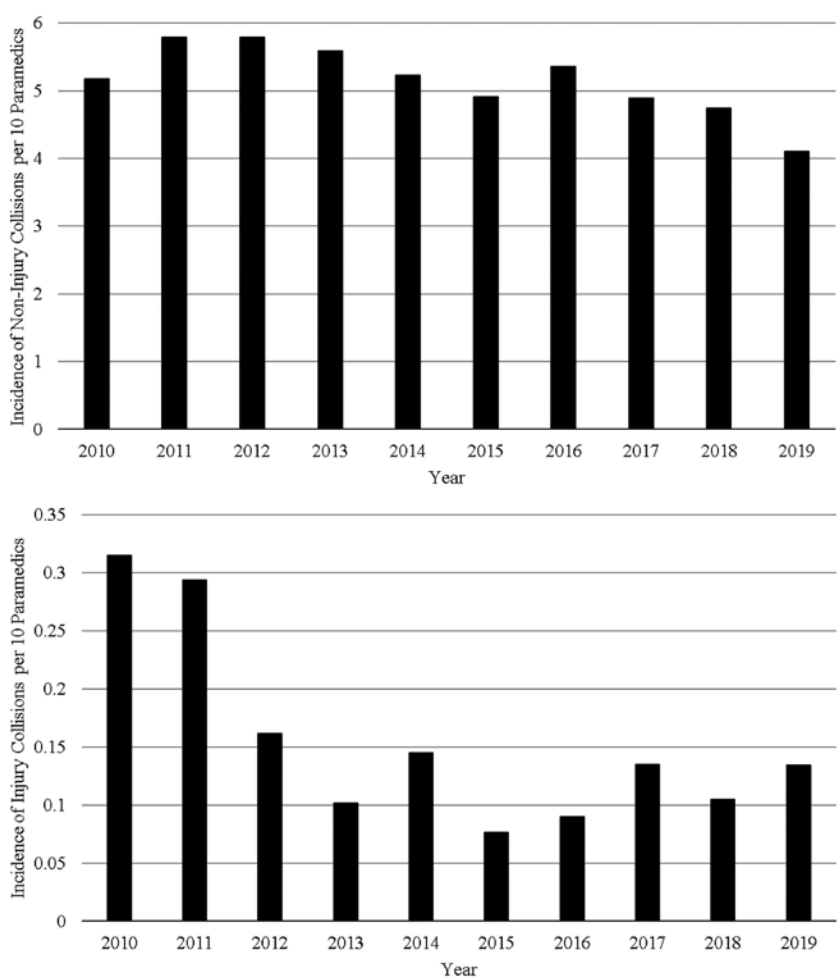

Figure 2. Incidence of Yearly Non-Injury (upper panel) and Injury (lower panel) Collisions between January 2010 and December 2020 in Montreal, Quebec.

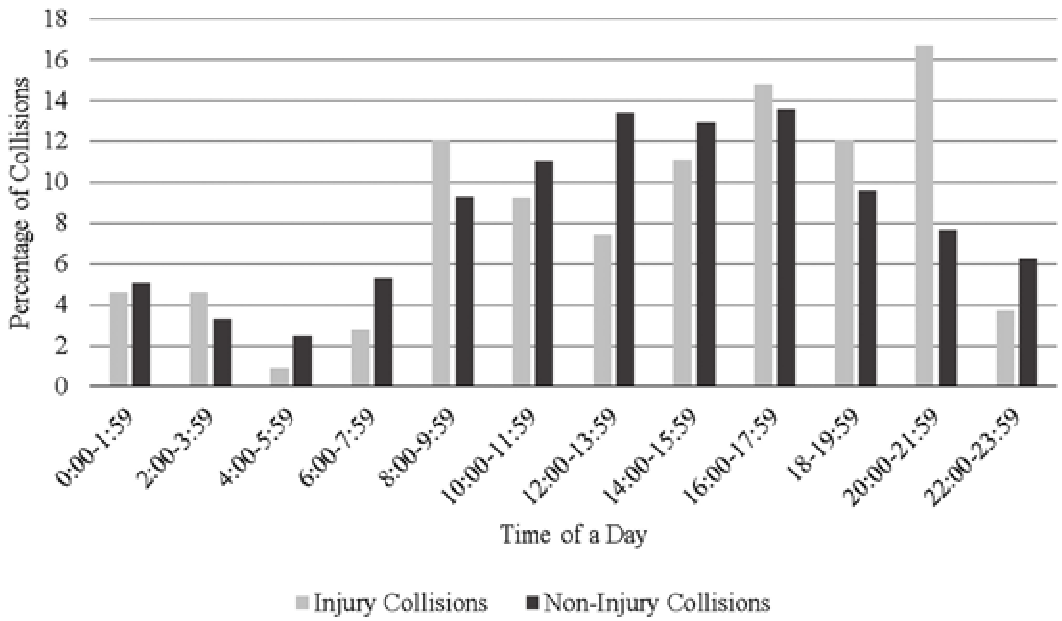

Figure 3. Distribution of collisions along a day.

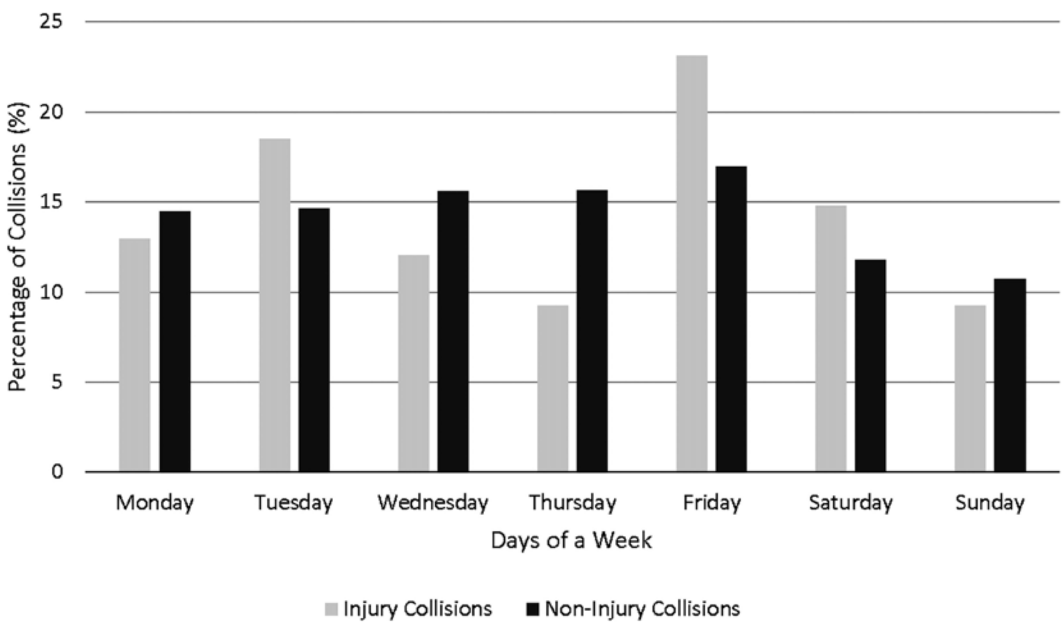

Figure 4. Distribution of collisions during a week.

pattern of non-injury collisions remains relatively constant throughout the week; however, injury collisions exhibit two spikes on Friday (23.15%) and Tuesday (18.52%). Friday has the highest number for both injury and non-injury collisions, counting 23.15% and 16.99% of the total, respectively.

Furthermore, the distribution of collisions severity (including injury and non-injury) among other variables like paramedic factors (e.g., experience, sex, and age of drivers), weather and surface conditions, environmental factors (e.g., type of environment, road topography, and signal type), day and time of the collision, and type of driving activity are shown in Table 2.

The number of male and female drivers involved in crashes is 3,672 and 961 cases, respectively. In detail, the number of injury collisions where males are involved is 78 more than females (93 vs. 15, respectively). The workforce consists of 27% females and 73% males in terms of gender distribution. In addition, there is no notable difference between male and female paramedics' involvement in non-injury collisions (0.50 vs. 0.53 collisions per paramedic, respectively). Also, the number of injury collisions per 10 paramedics is more for males compared to females (0.13 vs. 0.08, respectively).

Ambulance drivers between ages 25-45 are more involved in injury/non-injury collisions with 2,490 (out of 4,633) cases when compared to those outside this bracket. Moreover, paramedics aged 45 or older show a higher percentage of involvement in injury collisions (30.56%) compared to their younger counterparts aged 25 or less (12.04%). This might be due to a smaller number of staff aged less than 25 years old. Figure 5 shows a 3D distribution of the number of collisions per paramedic among different ages and experiences for both males and females. It shows that the number of young paramedics with low experience involved in multiple collisions is more than others. Additionally, there is a slight increase in the number of collisions among male paramedics over the age of 45.

Paramedic drivers with less than seven years of experience, most of them being younger, were involved in 2,437 collisions (2,384 non-injury and 53 injuries). Figure 5 shows a 3D plot to understand the intricate interplay between age, experience, and collision occurrences. By representing age and experience on the X and Y axes respectively, and collisions on the Z-axis, it aims to provide a comprehensive visual representation that not only showcases how collisions change with varying levels of experience and age but also highlights the joint impact of these variables on collision outcomes. According to this Figure, the number of collisions that involved paramedics ranging from seven to 20 years of experience reached 990 cases (963 non-injury and 27 injuries) and after that, it increased to 1206 collisions (1176 non-injury and 28 injuries) for paramedics with more than 20 years of experience, especially for male drivers.

In 23.82% (n: 1078) of non-injury and 19.44% (n: 21) of injury collisions, ambulance drivers were considered responsible for the collisions. And there is no clear answer for 66% of collisions on knowing who (civilian or ambulance drivers) is responsible for collisions. Furthermore, paramedic drivers with unknown use of seatbelts represent 2843 non-injury (62.83%) and 62 injuries (57.41%) crashes. The number of non-injury and injury collisions when they wear seatbelts is 1328 (29.35% of the total) and 41 (37.96% of the total), respectively.

In 37 injury cases (34.26%), the airbags were not deployed during the collisions, and for 67 cases, there is no answer on our database. This trend is observed for non-injury collisions with 1863 (41.17%) and 2645 (58.45%) cases for "not used" and "not answered" categories, respectively.

The driving activity was categorized into four groups: emergency driving (also known as the 10-30 code), non-emergency driving (also known as the 10-16 code), on-site, and others. In most of the cases in which the ambulance drivers were involved in the colli-

Variable	Category	Sub-Category	Non-Injury	Injury	Total
Paramedic Level Factors	Sex	Female	946 (20.91%)	15 (13.89%)	961
		Male	3579 (79.09%)	93 (86.11%)	3672
	Age	Less than 25	785 (17.35%)	13 (12.04%)	798
		Between 25 and 45	2428 (53.66%)	62 (57.41%)	2490
		More than 45	1312 (28.99%)	33 (30.56%)	1345
	Experience	Less than 7 year	2384 (52.69%)	53 (49.07%)	2437
		Between 7 and 20	963 (21.28%)	27 (25%)	990
		More than 20	1178 (26.03%)	28 (25.93%)	1206
	Responsibility	Yes	1078 (23.82%)	21 (19.44%)	1099
		No	406 (8.97%)	12 (11.11%)	418
		Shared	55 (1.22%)	2 (1.85%)	57
		Not answered	2986 (65.99%)	73 (67.59%)	3059
	Seatbelt	Yes	1328 (29.35%)	41 (37.96%)	1369
		No	354 (7.82%)	5 (4.63%)	359
		Not answered	2843 (62.83%)	62 (57.41%)	2905
	Localization	Rural	32 (0.71%)	0 (0.00%)	32
		Waiting area	38 (0.84%)	0 (0.00%)	38
		Operational Center	155 (3.43%)	0 (0.00%)	155
		Hospital	414 (9.15%)	0 (0.00%)	414
		Intersection	635 (14.03%)	47 (43.52%)	682
		Roadway between intersections	825 (18.23%)	23 (21.3%)	848
		Median strip	24 (0.53%)	1 (0.93%)	25
		Commercial Center	57 (1.26%)	0 (0.00%)	57
		Shoulder	67 (1.48%)	0 (0.00%)	67
		Land or private road	103 (2.28%)	0 (0.00%)	103
		Tunnel/Bridge	34 (0.75%)	0 (0.00%)	34
		Others and not answered	2141 (47.31%)	37 (34.26%)	2178
	Environment	Hospital	688 (15.2%)	0 (0.00%)	688
		Operation center	235 (5.19%)	0 (0.00%)	235
		Waiting area	65 (1.44%)	0 (0.00%)	65
		Residential	1224 (27.05%)	33 (30.56%)	1257
		Commercial	1243 (27.47%)	51 (47.22%)	1294
		Industrial	197 (4.35%)	5 (4.63%)	202
		Rural	239 (5.28%)	10 (9.26%)	249
		Others (e.g. school, park and parking lots) and not answered	634 (14.01%)	9 (8.33%)	643
	Road Topography	Flat/Straight	3431 (75.82%)	94 (87.04%)	3525
		Flat/Curve	213 (4.71%)	0 (0.00%)	213
		Hill/Straight	324 (7.16%)	7 (6.48%)	331
		Hill/Cruve	128 (2.83%)	3 (2.78%)	131
		Not answered	429 (9.48%)	4 (3.7%)	433
	Pavement Type	Asphalt	3789 (83.73%)	102 (94.44%)	3891
		Concrete	277 (6.12%)	1 (0.93%)	278
		Others (e.g. gravel)	459 (10.14%)	5 (4.63%)	464

Table 2. Descriptive analysis of ambulance collisions in Montreal from 2010 to 2019.

Variable	Category	Sub-Category	Non-Injury	Injury	Total
Paramedic Level Factors	Signalization	No Traffic light	2950 (65.19%)	33 (30.56%)	2983
		Traffic light	650 (14.36%)	55 (50.93%)	705
		Flashing red light	63 (1.39%)	2 (1.85%)	65
		Green light with priority	70 (1.55%)	2 (1.85%)	72
		Stop sign	57 (1.26%)	1 (0.93%)	58
		Obstacle(s) sign	716 (15.82%)	12 (11.11%)	728
		Others (e.g. pedestrian lights and flashing yellow light) and not answered	19 (0.42%)	3 (2.78%)	22
	Region	West	1829 (40.42%)	39 (36.11%)	1868
		East	2025 (44.75%)	38 (35.19%)	2063
		North	576 (12.73%)	30 (27.78%)	606
		Others	95 (2.1%)	1 (0.93%)	96
	Pavement Conditions	Good condition	3633 (80.29%)	97 (89.81%)	3730
		In Construction	148 (3.27%)	3 (2.78%)	151
		Under reparation	39 (0.86%)	1 (0.93%)	40
		Pot hole	143 (3.16%)	2 (1.85%)	145
		Others	562 (12.42%)	5 (4.63%)	567
Weather Conditions	Surface State	Dry	2710 (59.89%)	66 (61.11%)	2776
		Wet	609 (13.46%)	24 (22.22%)	633
		Snowy	488 (10.78%)	5 (4.63%)	493
		Icy	174 (3.85%)	4 (3.70%)	178
		Muddy & humid	67 (1.48%)	3 (2.78%)	70
		Others and not answered	477 (10.54%)	6 (5.56%)	483
	Weather Conditions	Black Ice	40 (0.88%)	0 (0.00%)	40
		Clear	2649 (58.54%)	66 (61.11%)	2715
		Covered	546 (12.07%)	13 (12.04%)	559
		Raining	256 (5.66%)	13 (12.04%)	269
		Snow/hail	231 (5.1%)	7 (6.48%)	238
		Gust of rain	87 (1.92%)	1 (0.93%)	88
		Strong winds	25 (0.55%)	1 (0.93%)	26
		Snowstorm	85 (1.88%)	0 (0.00%)	85
		Others (e.g. fog) and unknown	606 (13.39%)	7 (6.48%)	613
Vehicle	Airbag Used?	Yes	17 (0.38%)	4 (3.70%)	21
		No	1863 (41.17%)	37 (34.26%)	1900
		Not answered	2645 (58.45%)	67 (62.04%)	2712
Type of Task	Driving Activity	Emergency	1394 (30.81%)	67 (62.04%)	1461
		Non-emergency	1378 (30.45%)	22 (20.37%)	1400
		On-site	581 (12.84%)	1 (0.93%)	582
		Others	1172 (25.9%)	18 (16.67%)	1190
	Is there a Patient in the Ambulance?	Yes	1020 (22.54%)	33 (30.56%)	1053
		No	3017 (66.67%)	60 (55.56%)	3077
		Not answered	488 (10.78%)	15 (13.89%)	503

Table 2 (cont.). Descriptive analysis of ambulance collisions in Montreal from 2010 to 2019.

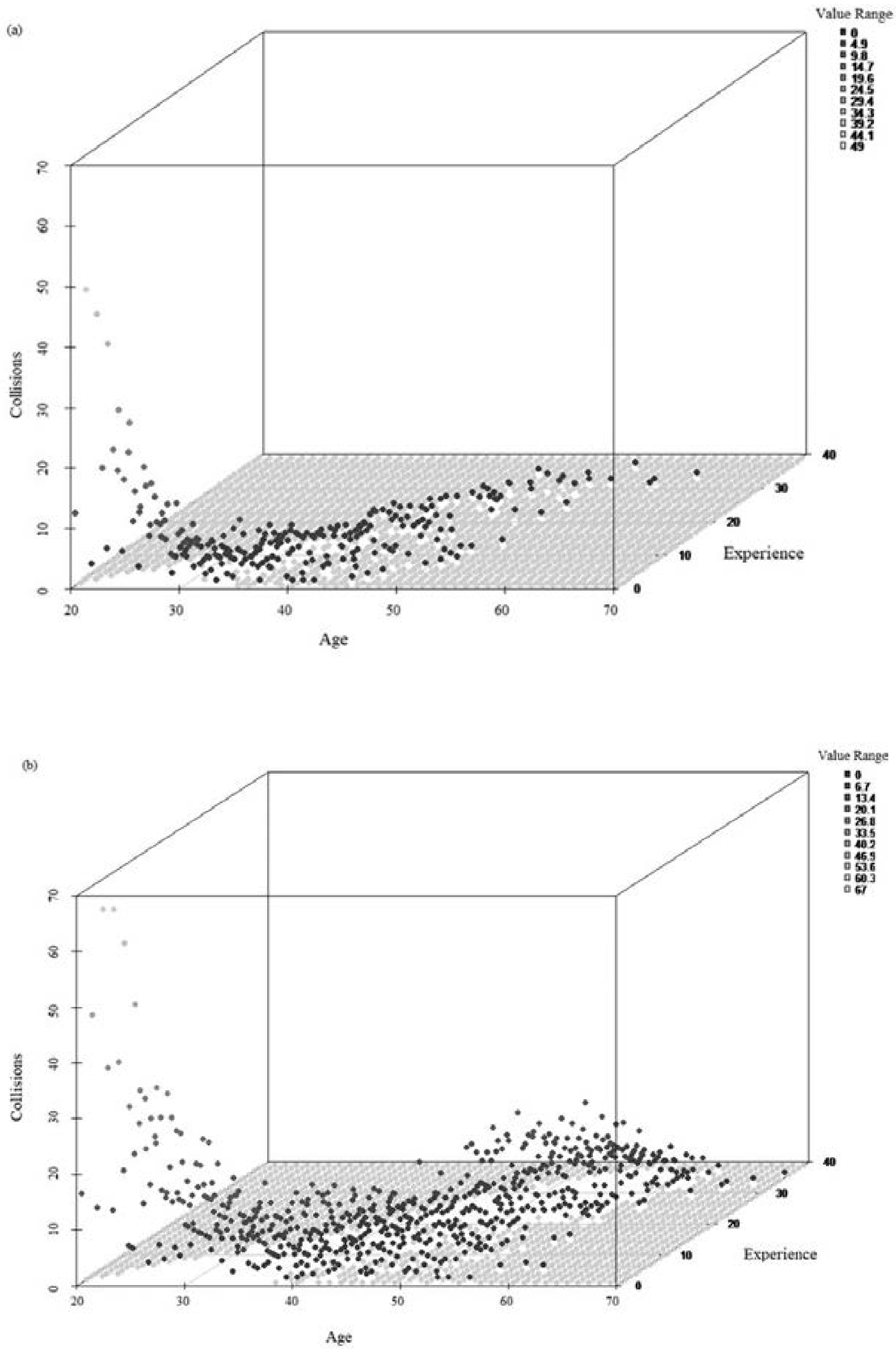

Figure 5. A 3D plot of collisions based on age and experience (a: female, b: male).

sion (especially for injury with 62.04% of total injury collisions), the crew was engaged in "emergency driving" with a total of 1,461 cases. Meanwhile, other levels of activity, including non-emergency driving, on-site, and others, had a total of 1400, 582, and 1190 cases, respectively. Also, there is no patient in the ambulance in 66.67% (n: 3,017) of non-injury and 55.56% (n: 60) of injury collisions.

In this study, four regions were used based on the Montréal Island: the north region, east region, west region, and other regions. The highest frequency of collisions can be seen in the east and the west regions of the territory with 2,063 and 1,868 cases, respectively. The north region exhibited 606 cases. Furthermore, there were more collisions reported in commercial and residential areas compared to other locations. Specifically, 1,294 collisions occurred in commercial areas, 1,257 in residential areas, and 688 in hospital areas. More precisely, intersections have the highest percentage of injury collisions (43.52%) compared to other areas like roadways between intersections (21.3%).

According to the weather conditions variables, the highest number of non-injuries (n: 2,649) and injury (n: 66) collisions happened when the sky was clear. In addition, 2776, 633, and 493 (out of 4633) collisions happened on a dry, wet, and snowy surface, respectively.

Flat/Straight areas exhibited 3,525 crashes, by far the largest number of cases of all areas, followed by Hill/Straight areas, which showed 331 cases. In addition, cases with no signalization showed 2950 (65.19%) cases, the largest number of cases in non-injury collisions, followed by cases with an obstacle sign, showing 716 (15.82%) cases. Traffic lights (n: 55) and no signalization (n: 33) are ranked in the top risky locations concerning injury collisions.

It should be mentioned that most collisions (n: 3,891) happened on asphalt pavement. Almost 81% of collisions happened when the pavement is in good condition. Only 336 crashes (7.25%) happened when the pavement is under construction, repair, or there are potholes on the pavement.

The effect of collision history on the total number of collisions for ambulance drivers during the studied period was examined with Pearson's product-moment correlation test. The null hypothesis of this test is that the true correlation is equal to zero. According to the results, there is a significant correlation (-0.383, 95%CI [-0.435, -0.327]; p-value< 0.0001) between the minimum interval separating individual paramedic's collisions and the overall number of collisions per ambulance driver. This means that by increasing the minimum interval of collisions, the total number of collisions per paramedic is expected to decrease. This trend is observed for the mean of intervals between collisions (-0.255, 95%CI [-0.313, -0.195]; p-value< 0.0001). In Table 3, the total number of collisions is presented for various interval cut-points, including the first to the fourth quartile of the minimum interval, as well as the mean of intervals between collisions for each ambulance driver. The results show that 36.5% and 24.91% of collisions are associated with drivers involved in collisions with a minimum interval of 28 days or less and a mean of intervals of 234 days or less.

Percentage	Minimum Interval				Mean Interval			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Cut-point of interval	28	85	283.5	2979	234.9	382	627.375	2979
Total number of collisions	1700	3042	4008	4657	1160	2651	3866	4657
Percentage (out of total collisions)	36.5	65.32	86.06	100	24.91	56.93	83.01	100

Table 3. Mean and Minimum of Intervals between collisions per ambulance driver.

Logit Regression

The logit regression results for the collision severity of ambulances are presented in Table 4. The VIF value for all variables used in this table is less than 5 which means there is no collinearity between variables. These tables provide the estimated odds ratios, standard error, z-value, p-values, and 95% confidence interval (CI) for each of the independent variables included in the models. The logit model demonstrated good performance as indicated by various goodness-of-fit measures such as Pseudo R2, the area under the ROC curve, and the percentage of correctly classified.

The models indicate that changing from emergency (baseline) to non-emergency, and on-site activities can lead to a reduction of 52% (95%CI; [75%, 6%]) and 92% (95%CI; [99%, 35%]) in odds of collision severity. "On-site activities" include tasks or operations that paramedics engage in at locations where the mission does not involve an emergency response. For example, collisions might occur in a hospital parking lot during non-emergency actions or at the CUS's vehicle depot.

Variables	Levels	Odds Ratio	Standard error	z-value	p-value	95% Confidence Interval	Pseudo R2	Area under ROC curve	Correctly classified
Activity	2	0.48	0.16	-2.15	0.03	[0.25, 0.94]	0.25	0.82	77.84%
	3	0.08	0.09	-2.36	0.02	[0.01, 0.65]			
	4	0.47	0.17	-2.03	0.04	[0.23, 0.97]			
Region	2	0.98	0.32	-0.07	0.94	[0.52, 1.85]			
	3	4.58	1.80	3.86	0.00	[2.12, 9.90]			
	4	0.21	0.26	-1.29	0.20	[0.02, 2.24]			
Surface Condition	2	1.47	0.55	1.03	0.30	[0.71, 3.05]			
	3	0.27	0.18	-1.99	0.05	[0.08, 0 .98]			
	4	1.13	0.83	0.17	0.87	[0.27, 4.78]			
	5	3.99	4.11	1.34	0.18	[0.53, 30.07]			
	6	0.66	0.46	-0.59	0.56	[0.17, 2.62]			
Signalisation	2	6.97	2.30	5.70	0.00	[3.58, 13.60]			
	3	0.87	0.82	-0.15	0.88	[0.14, 5.56]			
	4	3.08	3.10	1.11	0.27	[0.43, 22.24]			
	5	1.20	1.65	0.13	0.90	[0.08, 17.91]			
	6	2.10	1.17	1.33	0.19	[0.70, 6.27]			
	7	22.33	26.22	2.65	0.01	[2.24, 223.01]			

Table 4. Results of logit regression.

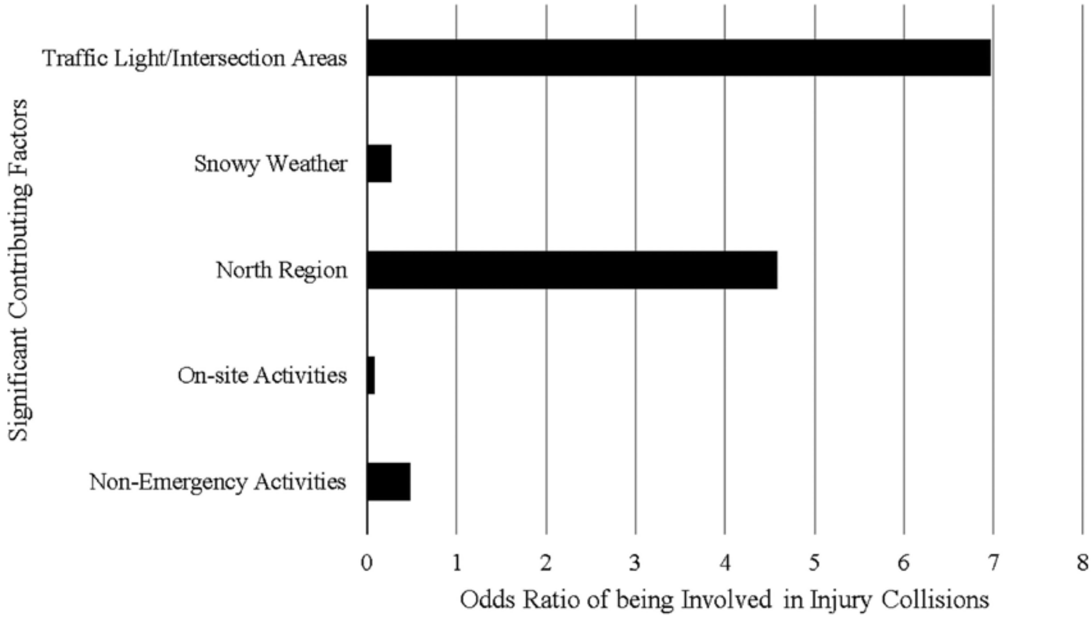

Figure 6. Summary of the effect of significant contributing factors on injury collisions.

Furthermore, trips in the north of Montréal lead to a high odds ratio (4.58, 95%CI; [2.12, 9.90]) compared to the other regions. The snowy surface is associated with a 73% (95%CI; [92%, 2%]) reduction in the odds of having an injury collision. Intersections with traffic lights can increase the odds of having a collision severity by 5.97 times (95%CI; [2.58, 12.60]) compared to no traffic light locations. The visual representation of the effect of these significant contributing factors on injury collisions is evident in Figure 6.

DISCUSSION

The primary focus of this study was to ascertain the factors contributing to the severity of work-related collisions within a paramedic corporation operating in the Montréal area (Quebec, Canada). The present results show that most ambulance collisions happen in urban environment areas such as commercial and residential. A study looking at ambulance collisions concluded that 82% of collisions occurred in an urban environment (Sanddal, Sanddal, Ward, & Stanley, 2010). Looking in detail, intersections have been identified as particularly risky locations, and the presence of traffic lights may increase the likelihood of injury collisions occurring. This is in line with multiple studies that worked on the location of collisions regarding emergency responders (Chiu et al., 2018; Custalow & Gravitz, 2004; Kahn, Pirrallo, & Kuhn, 2001; Lai et al., 2018; Pirrallo & Swor, 1994; Ray & Kupas, 2005). They confirmed that such locations are significant predictors of collisions and ambulances were more likely to be involved in them compared to others.

The date and time of collisions are associated with the frequency of ambulance collisions which is in line with the finding of Ray and Kupas (2005). Furthermore, the prevalence of non-injury and injury collisions is higher in the afternoon (23.82%; 12:00 to 15:59) and evening (26.85%; 16:00 to 19:59), respectively, which is consistent with other studies on the topic (Chiu et al., 2018; Drucker, 2013; Lai et al., 2018). This may be attributed to a variety of factors, such as the increased volume of emergency calls received during those times, as well as the heavier traffic on the roads, which can increase the likelihood of occurring a collision.

In more than 50% of collisions, ambulances did not have patients on board at the time of the collisions which is found in other literature (Sanddal et al., 2010). In addition, this study found that emergency activities can result in increasing the odds of collision's severity. Notably, the models indicate that changing from emergency to non-emergency, and on-site activities can substantially reduce the odds of collision severity. There are significant studies that concluded using lights and sirens or emergency mode can increase both frequency and severity of collisions. In this regard, there is a study that shows half of the collisions happened while using lights and sirens but did not find an association between emergency activities and an increase in the severity of the collisions (Biggers et al., 1996). This study shows most collisions happened in clear weather conditions and on dry surfaces. This fact is in line with previous literature about the effect of weather variables on ambulance collisions (Kahn et al., 2001; Pirrallo & Swor, 1994). However, it is found that the snow surface is associated with a reduction in the odds of having an injury collision. This might be due to a small proportion of calls or fewer crashes occurring in such kind of weather (Pirrallo & Swor, 1994). This could also be associated with an increased level of vigilance and preventive actions from paramedics while driving in such conditions, and thus to an overall reduction of collisions in such weather (Wilde, 1989).

Furthermore, it is found that cases with unknown seatbelt usage have a higher number of collisions for paramedics with 2,905 cases (out of 4,633), followed by those who wear it with 1,369 cases. This founding was reported in another study (Bentley & Levine, 2016). It is declared that 65.1% of paramedics were wearing seat belts when sitting in the front seat of the ambulance while 75.8% of their organizations have a written seat belt policy. And, almost no one (3.1%) during emergency mode reported using seat belts when in the patient compartment (Bentley & Levine, 2016). It is found that the chance of being killed or injured is significantly reduced by 3.77 times and 6.49 times, respectively, for ambulance occupants who are properly restrained (Becker et al., 2003). Therefore, specific interventions should be tailored to address this issue among paramedics since using seatbelts can improve the safety of both paramedics and civilian drivers. Moreover, one might assume that if the status of the seatbelt is identified as "unknown" while reporting the event, it is probably because it was not worn at the time of the collision.

Males were more involved in collisions compared to females (3672 vs. 961, respectively) which differs from a study with Maguire (Maguire, 2011) in terms of sex in paramedics' collisions (female: 53%). Or another study concluded that although females consist up 27% of employment, they were involved in 53% of collisions (Maguire, 2011). But the results of the study conducted by Boufous et al. (Boufous & Williamson, 2006) and Bellavance et al. (Bellavance, 2016) in terms of prevalence by sex in work-related collisions and other general kinds of literature on traffic safety confirm our findings (Choi, 2010; Claret et al., 2003; Durak, Fedakar, Türkmen, Akgöz, & Baduro lu, 2008; Mascarenhas et al., 2016). These results differ from the ones observed by Bellavance et al. (Bellavance, 2016) in terms of prevalence by sex in work-related collisions.

Furthermore, paramedics are more involved in collisions when they are young and have a lower level of experience, consistent with the general literature on road safety (Lloyd, Wilson, Mais, Deda, & Bhagat, 2015; Lyu, Cao, Wu, Xu, & Xie, 2018; Toroyan & Peden, 2007). Studies focused on ambulance drivers confirmed that the probability of being involved in collisions for such age categories is higher than others (Custalow & Gravitz, 2004; Galazkowski et al., 2015). Noting that the reason behind more involvement in collisions for ambulance drivers aged between 25 and 45 can be due to a higher staff count in this age group.

When an ambulance is involved in a collision while transporting a patient, it rapidly increases the risk of having injuries/deaths compared to other types of collisions, especially when the person being transported is already being taken care of for a particular health condition. To address this, we need to develop comprehensive proactive measures such as training programs designed specifically for less experienced drivers, or provide training on ambulance operators to focus on inadequate skills and abilities or operator errors (Elling et al., 2018; Boone et al., 2015). Use of emerging technology e.g., telematics devices (Levick & Swanson, 2005) can improve driver behavior. To achieve this goal, it's important to enhance the policies and standards for recruiting paramedics. By setting up clear and adaptable standards that consider the specific challenges of ambulance driving, and by integrating focused training and education plans, we can create a proactive strategy within the emergency medical services framework. This combined effort not only tackles the immediate issue of reducing collisions but also demonstrates a dedication to the ongoing safety and welfare of emergency personnel and the communities they serve.

LIMITATION

Exposure variables like the number of emergencies and non-emergency calls or miles driven in different regions, e.g., west and east regions of Montréal, are not available to see the possible reason behind the different distribution of collisions in such times and locations. The distribution of these exposure variables for different ranges of age, experience, and sex or in different weather conditions and activities including emergency and non-emergency are not accessible. In addition, this study is faced with a limitation regarding the number of paramedics with different experiences and age groups.

CONCLUSION

First responders' work-related collisions, especially among paramedics, are a major concern regarding road safety and health and safety. Also, the trend of ambulance collisions is not decreasing in Montréal during the studied period. It is concluded that male and young drivers with low experience (less than seven years) have a history of multiple collisions more than others. In addition, among risky locations, e.g., commercial and residential areas, crossing the intersections with traffic lights can increase the odds of collision severity significantly. Interventions aimed at reducing non-emergency and onsite activities could reduce significantly the odds of being involved in injury collisions compared to emergency calls. These key factors can help paramedicsÕ organizations to focus on target populations like young drivers or those who are involved in multiple collisions in a short timeline. Then, they could tailor either educational content for all or implement specific driving maneuvers programs that have been identified as problematic for their organizations and that have been shown promising in other clientele of drivers to reduce the burden of collisions (Tiesman et al., 2019) or inappropriate visual search as an example (Castellucci et al., 2020).

DATA AVAILABILITY STATEMENT

The data that supports this study's findings are available upon request from the corresponding author, ML. Data are not publicly available, due to ethical and privacy restrictions.

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RESEARCH REPORT

CHEMICAL INCIDENT PREPAREDNESS AMONG SWEDISH EMERGENCY MEDICAL SERVICE NURSES: A QUALITATIVE STUDY

Lina Gyllencreutz, PhD[1,2], Sofia Karlsson, PhD[2], Andreas Sjölander, MD[2], Johanna Björnstig[2], Pia Hedberg, PhD*[1,2]

Author Affiliations: 1. Department of Nursing, Surgery, Center of Disaster Medicine, Umeå University, Umeå Sweeden; 2. Department of Surgical and Perioperative Sciences, Surgery, Center of Disaster Medicine Umeå University, Umeå Sweeden.

**Corresponding Author*: pia.hedberg@umu.se

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ABSTRACT

Background: Hazardous chemicals are essential for modern society, but their use bears the risk of major incidents. Past incidents have revealed the importance of preparing and training emergency medical service (EMS) personnel when responding to these incidents. However, studies have shown the level of preparedness to be insufficient. There needs to be more knowledge about how EMS nurses perceive their preparedness and response when facing chemical incidents.

Aim: This study aimed to qualitatively investigate the working procedures regarding chemical incidents among a cohort of Swedish EMS nurses.

Method: Seventeen EMS nurses from rural and urban areas in Sweden were individually interviewed using four different realistic scenarios (vignettes). The transcribed text from the interviews was analyzed using qualitative content analysis.

Result: The results were derived into two categories with underlying sub-categories: a struggle to organize the onsite work situation (insufficient managerial support, limited resources, trust in rescue services, difficult decision making, stressful responsibilities) and decontamination—a demanding and risky situation (risk management, work in protective gear, aggravating circumstances). Participants often lack real-life experience in facing a chemical incident and training that improves preparedness and the ability to respond adequately.

Conclusion: Chemical incidents pose many challenges for EMS nurses, but with proper training efforts, many of these challenges can be solved. This study has shown the need for more accessible chemical incident training targeting EMS nurses, primarily focusing on risk assessment, managerial support, resource management, equipment, and decontamination, including stress management and decision-making. Research in chemical incidents is sparse, and there remains much to understand concerning work procedures during chemical incidents.

INTRODUCTION

Chemicals and chemical-based products are important for economic development and essential for modern life, and they are used daily in large quantities. Millions of potentially hazardous chemical substances are produced and transported globally daily. However, this also creates a considerable risk for chemical (C) incidents (World Health Organization, 2017). A C-incident is a harmful event that causes the spread of chemical substances or toxins into the environment. When a C-incident occurs, individuals and the environment are at risk of harm (Thornton et al., 2004; Barelli et al., 2008). In the case of a C- incident, intentional or not, the spread of a chemical substance constitutes a danger, regardless of where it may originate. C-incidents are potentially challenging due to the risk of rapid events, possibly leading to fatal consequences within minutes (Chilcott, 2014).

A tragic example is the devastating incident in Bhopal, India, in 1984, where clouds of isocyanate gas spread from a factory to a nearby residential area, causing over 8,000 deaths and a considerable number of injuries in the first week following exposure (Eckerman, 2011). A recent example is the Salisbury and Amesbury incident, where the Soviet-era Novichok class of nerve agent was used (Haslam, 2022). Concerns have been raised, and improvements are needed concerning C-incident prevention, preparedness, and response (International efforts for industrial and chemical accident prevention, preparedness, and response [Downloaded 23-08-22]. In the present paper, we considered preparedness (i.e., development of accident preparedness plans, early warning measures, communication with the public, and emergency exercises) and response (i.e., all the actions to be taken once an accident has occurred or there is an imminent threat of an accident) and investigate work procedures among EMS nurses.

Internationally, several major incidents have occurred over recent decades, and hundreds of C-incidents go unnoticed every year. In Sweden, there have only been relatively minor incidents involving chemical substances. However, one example of a severe C-incident is the chlorine gas incident at the bathing facility VanadisbadetÓ in Stockholm in 1993. A human mistake led to more than five cubic meters of chlorine gas being formed and released over the pool area. Thirty-one people, mostly children, were treated at the hospital (The National Board of Health and Welfare, 1996). Another example was an incident involving the release of ammonia at a food distribution factory in Helsingborg in 2010, where 16 workers were affected, and five had to be decontaminated in the hospital (Davidsson, 2010). Although these incidents did not involve a high number of deaths and thus seem undramatic, they indicate that these incidents could pose the potential risk of mass-casualty incidents (Khajehaminian et al., 2018).

EMS personnel, together with rescue services and the police, are typically the first responders to a C-incident and are responsible for incident management and onsite treatment of patients (Thompson et al., 2014). C-incidents pose a considerable risk to the first responders, as the spread of chemical material may seriously affect their health. There is also a risk of secondary contamination (whereby a victim contaminates first responders) during the response (Westman et al., 2021; Clarke et al., 2008). Generally, all first responders receive training in managing major incidents through Prehospital Healthcare Management (Rüter et al., 2006). However, in significant incidents like C-incidents, there is an additional need for knowledge and skills related to particular chemical substances. Studies have shown that successful and safe handling of C-incidents—including care of the injured in both the prehospital and hospital environment—requires careful planning, training, and preparedness (Kirk et al., 2007; Kenar & Karayilanoglu, 2004).

While it is generally true that all first responders in Europe are trained to manage significant events, there needs to be more C-incident preparedness among EMS personnel. EMS personnel have demonstrated inadequate training in responding to C-incidents involving a substantial number of exposed individuals. Challenges regarding resource allocation, treating chemical injuries, and effectively aiding contaminated victims have arisen (Jama & Kuisma, 2016; Davidson et al., 2019). In light of European studies, it is essential to study further how prepared EMS nurses consider themselves to be when facing incidents involving multiple injuries due to emissions of chemical substances.

Aim

This study aimed to qualitatively investigate the working procedures regarding chemical incidents among a cohort of Swedish EMS nurses.

METHODS

Study design

The design of this study was qualitative (Graneheim and Lundman, 2004). Data was collected through semi-structured individual interviews based on participant's reactions, discussions, and opinions to short story hypothetical scenario vignettes, which resemble realistic situations. This method is relevant for researching areas where empirical data is scarce or lacking (Schoenberg& Racdal, 2000). This design allows for an exploration of matters that are unique to the experiences of the participants and will contribute deeper insight into a phenomenon, which in the case of this study means how C-incidents are perceived, although participants lack real-life experiences (Schoenberg& Racdal, 2000; McGrath et al., 2019).

The four vignettes were constructed by an expert group of researchers and were based on disaster medicine research and grey literature (Newmark et al., 2016), actual incidents and models, and theories regarding major incident medical management (Mackway-Jones, 2014). Each vignette included one or more aspects important for prehospital medical management of major incidents, such as command and control, safety, communication, assessment, triage, treatment, and transport. (Figure 1.)

Participants

In this study, a cohort of EMS nurses from Sweden was recruited using a purposive sample; in this case, participants who had participated in a training course for risky environments such as C- incidents were asked to participate (n=8). Thereafter, a snowball sampling was executed as the first participants to enroll in the study reached out to potential colleagues interested in the phenomena (C-incidents) and asked them to participate (n=9).

In total, seventeen EMS nurses, both men (n= 9) and women (n= 8), aged 27 to 56 (mean 44) years, participated in the study. All participants but two had a specialist nursing degree in emergency care; their work experience as an EMS nurse was an average of 18 (4-36) years. In the Swedish EMS, all personnel are trained to handle major incidents through Prehospital Healthcare Management (Rüter et al., 2006). However, in major incidents like C-incidents, there is an additional need for knowledge and skills related to particular chemical substances.

You and your colleague received an alarm from SOS Alarm, which informs you that there has been a traffic incident on the main road, where a heavy goods vehicle drove into the ditch and overturned. The truck was carrying dangerous goods and how the driver fared is unclear. You arrive at the scene first, and emergency services are ten minutes away.
You and your colleague are alerted to a priority runner-up, but you come across this event on the way there, where you are first to arrive. You see a car burning heavily in a residential area near a preschool. As you get closer, you see an electric car on fire. The electric car has collided with a gas bus. Another motorist has stopped, and a person is on his way forward with a hand-held fire extinguisher. Around the site, several passers-by have stopped, and some are filming the incident with their smartphones.
You and your colleague arrive at an apartment building. SOS Alarm informs you that they have received several calls from residents of the house stating that they feel dizzy, lethargic, and nauseous, they are coughing, and that some have lost consciousness. At the same time, those affected indicate that they smell something strange, which becomes stronger in the stairwell. Emergency services and police are on site, and emergency services are evacuating all residents out of the house after they discover a drug lab in the kitchen of one of the apartments with several unmarked chemicals. You will work here on site with the evacuees.
You and your colleague are alerted regarding an incident in the local battery factory. When you arrive, you are informed by the supervisor that there has been an incident in production and that a large amount of corrosive substance has been spilled. At least seven people have had this corrosive substance on them. Eight people from emergency services who have entered the factory discover that their clothes are starting to corrode and that their skin is starting to react. Two of the factory workers who have had a significant amount of corrosive substance on them are assessed as critical and need rapid transport, and you have access to ambulances for transport to the hospital.

Figure 1. Vignettes used in the study.

Data collection

Individual semi-structured interviews were performed via digital platforms. The interview started with the interviewer presenting the vignette on a PowerPoint slide.

The discussion started with the interviewer reading the vignette out loud and then asking: "What would you do?" The vignette included aspects that the participants could interpret in different ways. Depending on the participant;s answers, the interviewer asked questions to support discussions about alternative solutions. In that way, the interviewer and participant interaction shaped a unique narrative and gained an even more nuanced answer. The interviews lasted for a mean of 78 minutes (min: 0:49, max: 1:48), and. Interviews were taped and transcribed verbatim.

Analysis

The interview text was analyzed using qualitative content analysis (Graneheim & Lundman, 2004; Graneheim et al., 2017), where qualitative data is analyzed systematically. It involves interpretations and descriptions at different levels of abstraction (Lindgren et al., 2020). The original interview text was broken down into meaning units and labeled as codes using MS Word. The codes were sorted by similarities and differences and abstracted into sub-categories and categories. Categories, sub-categories, and participant quotes made up the final presented results.

Ethics

This study was performed according to the Helsinki Declaration (WHO, 2013). Study participants are professionals and not patients, thereby not regulated by The Act concerning the Ethical Review of Research Involving Humans (2003). All participation in the study was voluntary. Full informed consent was given by participants with the option to withdraw from the study at any time. Results were presented at the group level, and individual participants cannot be identified.

RESULTS

A struggle to organize the onsite work situation

Insufficient managerial support

Categories	Subcategories
A struggle to organize the onsite work situation	Insufficient managerial support
	Limited resources
	Trust in rescue services
	Difficult decision-making
	Stressful responsibilities
Decontamination—a demanding and risky situation	Risk management
	Work in protective gear
	Aggravating circumstances

Table 1. Categories and subcategories.

Participants' descriptions of onsite management were that it was insufficient and poorly structured even though they stated that they relied on their onsite work regarding concepts (Prehospital Healthcare Management) and recognized the tools for rapid patient assessment (Airway, Breathing, Circulation, Disability, and Exposure). EMS managerial support appeared to be minimal to non-existent compared to rescue service support. It was stated that rescue services had well-developed onsite support and incorporated support management in education. Participants described that organizational support from other EMS colleagues was needed within EMS to handle onsite management. Lack of support was experienced as problematic.

"If we compare us to the rescue services, they know who their onsite officer is; with us it may be a new unexperienced employee who will act as onsite manager." [Male, age 55, experience 33 years, no risky environments course].

It emerged that an early establishment of collaboration with rescue services and the police appears to be essential for the EMS commander to manage onsite teams. Cooperation emerged as necessary for the EMS commander to establish effective and safe care of the injured. The EMS commander will not be able to section the incident scene into different zones unless cooperation with the rescue service commander is established.

The participants highlighted zones as the foundation for strategy—planning, re-evaluation of the incident, and care of the injured. Zones at the incident site were also important for the commander's work procedures, as the level of personal protective gear and decontamination of victims varies due to different safety zones.

"When it comes to the EMS part, it is extremely insufficient, we are talking it's now 2021 and we have no digital support in management." [Male, age 55, experience 30 years, risky environments course].

Limited resources

The distribution of resources proved to be a significant problem, as the nature of most C-incidents might involve many injured persons. To request extensive resources early on came across as advantageous. The availability of resources differs depending on the location of the C-incident, and what time of the day and what day of the week the incident occurred. In the case of a rural location, the general experience was that resources would be sparse, and it would be difficult to receive resources at the incident site within a reasonable timeframe. This makes distributing and utilizing resources more challenging, and participants expressed that they would have to make uncomfortable decisions in an already difficult situation.

"I think the whole work will suffer and become more cumbersome if you do not have enough ambulances; it is definitely a question of resources. It will affect both the direction in decision-making, and it will affect the outcome for the patient." [Male, age 31, experience 6 years, no risky environments course].

Moreover, considering onsite resources and conveying information to and preparing hospitals for receiving the injured were emphasized as significant. Early notification to hospitals, the requirement for further decontamination upon arrival, and an onsite report of the situation were especially important for organizing work. This was mentioned to give the receiving hospital time to gather resources and prepare.

Trust in rescue services

Participants described having confidence in the rescue service commander to take control of the onsite situation. They considered the rescue service commander—compared to themselves as commanders—to have appropriate knowledge on how to make adequate risk assessments and decisions about safe approaches to the chemical incident site. Rescue services personnel have suitable equipment and protective gear and were considered better educated managing C-incidents.

Difficult decision-making

When decisions relevant to EMS nurse's work situation were delegated to the rescue service commander, for example the decision on when it was safe enough to access victims, the participants experienced a delaying in reaching the victims. Trust in rescue services was discussed as an advantage but also as a hindrance if rescue services personnel were, for any reason, absent at the incident site, in which case it could be a problem if the EMS commander is insecure about how to manage C-incidents.

"Once rescue services arrive, we can definitely lean on them." [Male, age 39, experience 10 years, no risky environments course].

Participants described decision-making during a C-incident as more critical, time-sensitive, and, therefore, more challenging than general emergencies. Decisions that addressed the level of care to patients were in focus and based on the current situation and resources. The participants stated that all decisions were based on whether there were lives to save. If there were, the decision required treatment provision. No treatment provision was required for patients with a low chance of survival. It was stated that more experience and training were needed in making such uncomfortable and difficult decisions. In contrast, participants with long work experience expressed less insecurity and fewer uncomfortable feelings than their less experienced colleagues.

"...it's a very difficult situation and very difficult to make that decision. It's probably one of the situations that clenches my stomach. At the same time, we have the resources that we have. Then you might focus on those you can save instead of those who are seemingly beyond rescue..." [Male, age 31, experience 6 years, no risky environments course].

Stressful responsibilities

The participants described that the ability to be flexible was needed to handle stressful and unpredictable C-incidents. Adapting and preparing mentally for the specific situation would help EMS nurses handle stress and improve their response. It emerged that the participants' work procedure for handling the unpredictable was not generic, and they expressed a need to discuss strategies for handling stressful situations.

"...this is something that you mentally wish to have gone through before that you are not surprised by difficult decisions that you actually have to make. For example, prioritize down patients in need, deviate from routines, send several patients in one and the same ambulance... There are many things that are different from the usual ambulance work you do." [Male, age 39, experience 10 years, risky environments course].

Participants described how to consult the Swedish Poison Information Center to gain better knowledge of the chemical's impact and how to handle and treat exposed patients, especially with antidotes. A common symptom when exposed to chemicals would be coughing and a high respiratory rate, which was described as relatively easy and straightforward to treat. The participants described how these patients needed to be taken outside for fresh air and then treated with oxygen and inhalation medication. If there were signs of smoke inhalation poisoning, the patient should be treated with medications.

"...you need to know what chemical it is... I would use the Swedish Poison Information Center and then I would presumably have to state... I have my current scenario and these symptoms...

Then we would probably start treating symptoms." [Female, age 46, experience 27 years, risky environments course].

Decontamination—a demanding and risky situation

Risk management

One challenge in managing risk was obtaining an overview of the situation and gaining sufficient information about the chemicals involved. It was stated that initial decisions were based on what was visible at the incident site. However, this could be treacherous as some chemicals, e.g., gas, are invisible and, therefore, very hard to detect. Participants were better acquainted with chemicals such as petroleum products, but they were more uncertain when facing batteries and corrosive materials.

"If we don't know what it is about, it will be very difficult to think about what the consequences may be... But you have to keep in mind that it can have many consequences when we don't know what it is about and what the consequences are for the patients." [Female, age 29, experience 4 years, no risky environments course].

It emerged that managing risks onsite at the C-incident was crucial for EMS work procedures and often posed several challenges. One challenge was that all EMS nurses were responsible for their safety and should not act in any way that could expose themselves, or others, to unnecessary risks.

Participants said that undressing and washing the patient with water was essential. However, EMS nurses could not be responsible for the decontamination, as they do not have any equipment. Thus, they rely on rescue service personnel to carry out the decontamination. The degree of decontamination required depends on what chemical was involved and the patient's condition.

"...Even if they (patients) are in a bad condition, you have to... decontaminate and get them into the ambulance... Some corrosive substances cannot be rinsed off with water only, since water can aggravate the corrosion even more. You have to find out what kind of corrosive substance they have on their body and how we... get off the clothes..." [Male, age 54, experience 30 years, no risky environments course].

The participants described solutions to prevent secondary contamination, such as wrapping the patient in sealing material (e.g., bubble wrap or blankets) before transport. However, depending on how critical the patient's condition was, the decision was not easy, and participants described being uncomfortable about transporting a patient unless they had been decontaminated in some way.

"...we have to prioritize, scrub with soap and water, and they will be wrapped in blankets and transported. Then you get to find out about these chemicals and how they... yes, so that we are not affected..." [Male, age 54, experience 30 years, no risky environments course].

A challenge related to risk management that was described as frustrating was the complicated task of clearing the uninjured and bystanders from the incident site, as they could make the situation even worse. A general experience expressed by participants was that some bystanders did not listen to them. Participants described that they tried to position the ambulance so that it would hinder people from accessing the incident site or tell them to evacuate to a safe area. The fact that some bystanders intentionally put themselves at risk and were unaware of the potential consequences was highlighted as a problem.

"…today they don't care in what we have to say, and it is up to the police to remove them… we have an obligation to warn and inform them but if they don't care about what we have to say they have themselves to blame. Everyone is responsible for their own actions, and it is up to the police to remove them. It's not our job, we can only warn them." [Male, age 54, experience 30 years, no risky environments course].

Work in protective gear

It emerged that the EMS's everyday work wear was not suitable to work at the scene of a C-incident, although this was what would happen if they were dispatched to a C-incident. It was stated that protective gear was rarely included in ambulance inventories, and thus, participants described that EMS nurses generally lacked the equipment to handle chemical substances if they dispatched to a C-incident. Moreover, it was described and experienced that working in protective gear was difficult.

"…no, we do not have much protective gear… the equipment we have and could use is at the ambulance station and we are already out on the roads and do not have the opportunity to take it with us, so we have no protective equipment." [Male, age 27, experience 7 years, no risky environments course].

Regarding what level of protective gear is required for the EMS nurses at the incident site, participants highlighted consideration of what chemical substances personnel might be exposed. The chemical substance at play will guide decisions as to the required level of security. However, having access to adequate protective gear and equipment in the ambulance vehicles was something participants requested. Participants stated that corrosive substances were the most hazardous and difficult to handle without proper protective gear.

When working with chemically contaminated patients, the ambulance and the protective gear the EMS nurses wear may become contaminated, requiring careful decontamination before the ambulance vehicle can be used again. It became clear during the interviews that the process of decontaminating an ambulance differed depending on who in the EMS crew was responsible. Lack of information on how this procedure should be done was the reason. The respondents said they experienced that the Emergency Department had more elaborate routines for decontamination.

"...you have to be aware that if there was a chemical release, you have to be conscious of how you remove this. Then what do I do with this substance, it's not just throwing it in the trash." [Male, age 55, experience 30 years, risky environments course].

Aggravating circumstances

Exposure to chemicals, especially those in batteries, gases, or corrosive substances, makes any situation more difficult. Risk of explosion, fire/smoke, and unknown gas were named "no-approach" risks. Participants referred to no-approach risks posing such a great threat that patients could not be approached safely. However, no-approach situations could vary. For example, approaching vehicles with battery packs—such as hybrid or electric cars—should be done cautiously.

"We are very concerned about safety because we are our own safety representatives as well. In that way, we do not approach something that is not safe." [Male, age 31, experience 6 years, no risky environments course].

Another example of the complexity of no-approach risk that came up during the interviews was assessing patients in potentially deadly situations, e.g., in a burning vehicle, in trucks carrying unknown cargo, or in a hazardous environment. Participants stated that one way to manage the risks of the situation was to try to have the patient evacuate on their own. However, actions not in line with no-approach risks were described in a scenario where this was not possible. One suggestion was that despite the awareness of the risk and consequences it may have for their own safety, they would run to the scene and try to pull the patient out of the burning vehicle into the safe zone. However, it was also stated that it would never be acceptable to take such risks and attending to patients should always be done in accordance with standardized working procedures. Once the patient was in the safe zone, participants were confident in their ability to examine patients using the tool for rapid patient assessment used in non-chemical injuries.

DISCUSSION

The main findings are that EMS nurses perceive a lack of support when arriving at the scene of an emergency. The legislation concerning workplace safety needs to be proactively reviewed to prevent any EMS nurses from being injured or losing their health or lives due to inadequate equipment. Compared with the rescue service, the role of EMS at the scene depends on the first ambulance arriving at the incident site. Thus, the experience of the crew in the ambulance could be insufficient. EMS personnel did not feel confident at the scene without rescue services. In the case of an ambulance being the lone first responder and no rescue service yet on site, EMS personnel must be able to handle the situation. Responding to C-incidents means stressful responsibilities and difficult decision-making, adding to an already challenging situation. These findings correspond to previous studies that show that the treatment of chemically effected patients in the field needs to be improved (Maguire et al., 2007; Phelps, 2007; Jama & Kuisma, 2016).

The results of this study also state that EMS protective gear needs to be improved. The result reveals that EMS nurses must adopt more extensive safety measures on-scene at a C-incident than are usually required. The participants described this as not easily attainable, as most ambulance vehicles do not carry extended safety equipment. Furthermore, the results show that personal protective gear was unsuitable for protection against chemicals and was not easy to work in when performing standard work procedures. It is argued that standard EMS protective gear will provide little protection against chemical contamination (Monteith & Pearce, 2015). The legislation concerning workplace safety needs to be proactively reviewed to prevent any EMS personnel from getting injured or losing their health or lives due to inadequate equipment. Not being able to access a C-incident in a safely would critically delay the management of patients and intensify the stress placed on EMS nurses. An aspect that needs to be considered is that working in chemical protective gear is challenging (Wiyor et al., 2020). Appropriate protective gear in the ambulances and periodic scenario training with protective gear would contribute to EMS nurses' safety at the incident scene and faster management and treatment of patients.

Another result is that an early start to the decontamination procedure was stated as essential for both patient health and response effectiveness. However, this result indicates that an incident in a rural area complicates an early start due to prolonged transportation time. It is unclear, however, how the condition of rural areas impacts the amount of time a patient is in contact with a contaminant (Ingrassia et al., 2014). Additionally, previous studies also indicate that patients in rural areas have higher overall prehospital mortality following injury, and mortality risk increases with the degree of ruralness in which a patient is situated (Jarman et al., 2019; Keeves et al., 2019). Specific knowledge of the relationship between the health of the decontaminated patient and the specific chemicals and time to treatment needs to be included in training personnel to support effective response.

The results also suggest that working procedures involving electric vehicles were laced with uncertainty, and the initial response needed to be handled carefully. As incidents with electric vehicles are becoming more common, and EMS nurses are uncomfortable with this situation, this issue calls for further attention. Since there has been limited research in this area, more research is needed to map out the potential dangers for EMS personnel when working with patients involved in an incident with electric vehicles (Thermaenius et al., 2022; Liu et al., 2023).

Another point in the result highlighted stressful responsibilities. The results show that mentally adapting and preparing for a specific situation would help EMS nurses handle the stressful C-incident and improve their ability to feel confident about the situation. Studies have shown the importance of coping strategies in handling stress, especially when it comes to preventing Post-Traumatic Stress Disorder PTSD (Hruska & Bardhun, 2021). Furthermore, acute negative stress has also been proven to lower the quality of EMS personnel's decision-making and patient care (Regehr & LeBlanc, 2017; Eiche et al., 20191). Whether the training given to EMS personnel (Mackway-Jones 2014) provides resources such as knowledge and capability in coping with the situational demands of C-incidents has not yet been evaluated.

Methodological considerations

This study used a qualitative design (Graneheim & Lundman, 2004; Graneheim et al., 2017). In qualitative design, trustworthiness is a central concept of the analysis, which, in turn, summarizes the different aspects of credibility, dependability, and transferability (Lindgren et al., 2020).

The fact that an expert group of researchers constructed the four vignettes and that the researchers participated throughout the analysis process strengthened the dependability of this study. Using vignettes to explore participantsÕ experiences of work procedures in C-incidents increases the result's credibility.

A purposive sample of participants who had participated in a training course in risky environments increased the study's credibility. However, snowball sampling is reliable, as all Swedish EMS nurses might be dispatched to a C-incident.

Because most EMS nurses do not have experience with C-incident response, the vignette-based interviews and the interaction between the interviewer and the participant strengthen credibility. The interviews were thorough and contained extensive stories with rich and detailed insights about C-incident response. However, in qualitative research studies, it can never be excluded that another study cohort, the timing of the data collection, or the vignettes forming the basis of this study might have influenced the results.

The description of the participants' demographics and experience increases the possibility for the reader to decide on the relevance of transferring the results to another context. A clearer description of previous work experience could have increased transferability.

CONCLUSION

The results of this study show that EMS nurses face many challenges when handling a C-incident, such as a lack of support and protective gear and insufficient knowledge about particular C-incidents (e.g., electric vehicles or incidents in rural areas). All these challenges impact EMS nurses' feelings of insecurity related to C-incident response. Training that improves preparedness and the ability to respond adequately, such as collaboration exercises is requested, which also emphasizes the need for research in multidisciplinary fields to fill the knowledge gap of EMS nurses' work procedures regarding chemical incidents.

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RESEARCH REPORT

ASSESSING THE FEASIBILITY OF ON-SHIFT SIMULATION TO IMPROVE CAPACITY ASSESSMENTS BY EMS CLINICIANS: A PILOT PROJECT

Daniel DuPont, MD, MBE, EMT-PHP*[1] Jonathan Bar, MD[2]; James Baca, MBA, FACHE, EMT-P[3]; Krystal Hunter, PhD, MBA[4], Alexander Kuc, MD[1]; Aman Shah, MD[1]; Gerard Carroll, MD, FAAEM, FAEMS, EMT-P[1]

Author Affiliations: 1. Division of EMS and Disaster Medicine, Department of Emergency Medicine, Cooper Medical School of Rowan University, Camden, NJ, USA; 2. Department of Emergency Medicine, University of Pennsylvania, Philadelphia, PA, USA; 3. Simulation Laboratory, Cooper Medical School of Rowan University, Camden, NJ, USA; 4. Cooper Research Institute, Cooper Medical School of Rowan University, Camden, NJ, USA.

**Corresponding Author*: dandupont232@gmail.com

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ABSTRACT

Objective: Determining the decision-making capacity of patients in the prehospital setting is a high-risk area for EMS agencies. This risk is only enhanced by the growing prevalence of mental health, neurological, and substance use disorders. This study sought to evaluate the feasibility of on-shift simulation as an educational method, in this case to improve EMS clinicians' ability and confidence in performing capacity assessments.

Methods: This was a prospective feasibility study performed at an urban hospital-based EMS service. All participants were active EMTs or Paramedics. Subjects completed a written pretest containing 10 patient scenarios addressing specific components of capacity assessments. For each, participants were asked to decide if the patient had capacity and to rate how confident they were in their answer. They then participated in an educational session involving a simulated patient encounter and debrief, designed to evaluate, and teach skills in capacity assessment, while on shift. Lastly, subjects took a posttest consisting of the same scenarios and confidence assessments as the pretest.

Results: It was feasible for EMS clinicians to complete an educational simulation session while on shift, with 26 subjects being recruited and 22 (85%) completing the full study protocol. While there was no significant difference between the number of scenarios answered correctly before and after the intervention (9.18 vs 9.27), confidence scores did significantly increase (87.2 to 95.2, $p < 0.001$). This increase was driven by scenarios pertaining to pediatrics, mild dementia, and substance use.

Conclusions: EMS clinicians were able to complete an educational session including a simulated patient encounter and debrief while on shift. The intervention led to a significant increase in confidence in performing capacity assessments without a significant change in the number of scenarios adjudicated correctly. This study revealed specific areas in which clinicians would likely benefit from further education, but further research is needed to help establish generalizability.

INTRODUCTION

The burden of mental health, neurological, and substance use disorders has been increasing worldwide (Patel et al., 2016). As of 2016, more than one billion people were afflicted by psychiatric and substance use disorders, accounting for 7% of global disease burden (Rehm & Shield, 2019). This subset of patients has been shown to require increased use of EMS (Duncan et al., 2019; Knowlton et al., 2013; Larkin et al., 2006). When EMS clinicians encounter these patients, they are faced with numerous challenges, especially when the patient is attempting to refuse medical treatment and/or transport to the hospital.

These situations represent very high-risk situations for EMS agencies, both clinically and medicolegally. If patients who lack the capacity to refuse treatment and/or transport are allowed to do so and then deteriorate later, the EMS agency and its personnel risk facing charges of negligence or patient abandonment (Colwell et al., 1999; Morgan et al., 1994; Wang et al., 2008). Furthermore, if patients with capacity to refuse are taken to the hospital against their will, allegations of assault, battery, or, in rare cases, wrongful imprisonment may ensue (Weaver et al., 2000). EMS personnel must be skilled in assessing patients and accurately determining their capacity to make medical decisions for themselves.

The existing literature on the ability of EMS clinicians to assess capacity is sparse. O'Connor et al. (2010) evaluated inter-rater agreement between prehospital personnel and physicians who were asked to listen to 30 medical control calls and interpret whether the patients involved had capacity. Participants also reported their confidence in their decisions. Ultimately, inter-rater reliability both between and among the cohorts was poor. The authors suggest that capacity assessment has not been sufficiently standardized or validated in emergency medicine and they advocate for further study. There is also a dearth of literature on how to best educate prehospital clinicians on how to perform capacity assessments. In one study, authors evaluated the documentation of capacity by advanced life support (ALS) clinicians at one month and one year after a 1.5-hour educational module on decision-making capacity. They found that there was no difference in documentation (Riley et al., 2004).

Simulation is common in EMS education (McKenna et al., 2015). Previous research demonstrates its benefits (Gurňáková & Gröpel, 2019; Gordon et al., 2005; Hall et al., 2005) but has not examined the use of simulation while on shift or the use of simulation to teach or evaluate capacity assessment. The primary objective of this pilot study was to evaluate the feasibility of on-shift simulation as an educational method. In this case, on-shift simulation was used to teach EMS clinicians to better assess capacity. Their ability to do so and confidence in that ability were assessed as secondary objectives.

DESCRIPTION AND METHODS

Study Design and Setting

This was a prospective feasibility study performed at an urban, tertiary, academic medical center (Cooper University Hospital) that has a hospital-based EMS service (Cooper EMS). Cooper EMS is a two-tiered service primarily utilizing Emergency Medical Technicians (EMTs) and paramedics with additional support from a 24-hour paramedic supervisor response vehicle and EMS physician response units. The Cooper University Hospital Institutional Review Board approved this research study.

Participants and Intervention

Participants were considered eligible for recruitment if they were 18 years of age or older and were currently working clinically for Cooper EMS as an EMT or Paramedic. They were recruited via email or in-person solicitation.

Participants first completed a pretest. The pretest gathered demographic information and contained 10 patient scenarios. Each scenario consisted of a patient who wanted to refuse care with a different factor complicating the refusal. The ten factors were religious beliefs, head injury on blood thinners, withdrawal after naloxone, refusal to participate in the assessment, mild dementia, competing family emergency, pediatric patient, active labor, report of suicidal ideation from family, and intoxication.

For each scenario, participants were asked to determine whether the patient had capacity to refuse and to rate their confidence in their answer on an ordinal Likert scale. The scenarios were written by one of the authors (JB) and then refined by the rest of the EMS physician group until each case was felt to be clearly worded and unanimous agreement was reached on a correct answer. The scenarios were then trialed by EMS clinicians from two separate agencies to ensure that the scenarios were unambiguous and written at an appropriate level. These clinicians did not participate in the rest of the study.

After the pretest, the subjects participated in a live simulation exercise at a local simulation center. In the simulation, an actor portrayed a standardized patient with mild intoxication and a head injury who wanted to refuse care. The scenario was designed to evaluate and teach skills in capacity assessment. Each participant's performance in the exercise was evaluated using a standardized script and a checklist of critical action items. A post-scenario debrief including a general review of capacity evaluation was conducted. Participants were allowed to ask general questions, but specific questions about test scenarios were not answered. The full sessions lasted approximately 30 minutes.

The simulation sessions were conducted during participants' normal scheduled shifts. Cooper EMS fields 60 hours of Advanced Life Support ambulance coverage and 96 hours of Basic Life Support ambulance coverage per day, averaging 80 daily dispatches. Call volume permitting, on-shift crew members who had completed the pretest were taken out of service and went to a medical school simulation center in their response area while the other units covered emergency calls.

After the simulation session, participants were asked to complete a posttest containing the same scenarios as the pretest assessment. Posttests were completed an average of one to two weeks after the simulation session.

Outcomes and Statistical Analysis

The primary objective of this study was to determine whether it was feasible for EMS clinicians to complete an educational simulated patient encounter while on shift, measured as the percentage of enrolled participants who completed the simulation session and posttest. Improvement in pre- and posttest correctness and confidence scores were measured as secondary outcomes. All test score comparisons between EMTs and paramedics were completed using independent t tests. Comparisons between pre- and posttest questions were analyzed using a paired t test.

RESULTS

It was feasible for EMS clinicians to complete an educational simulation session while on shift. 26 subjects completed the pretest. Of those, 22 (85%) completed the full study protocol. Of the 22 who completed the posttest, 19 (86%) were male and 10 (45%) were paramedics. One female paramedic completed the study. Subgroup analyses were not performed due to small numbers.

There was no significant change in the number of scenarios that participants answered correctly on the pretest and posttest. Mean scores (out of 10) on the pretest and posttest were 9.18 (+/- 0.96) and 9.27 (+/- 0.88), respectively ($p = 0.747$). Subjects' confidence in their answers, however, increased by a modest but statistically significant amount. Total mean confidence scores (out of 100) improved from 87.2 (+/-10.06) to 95.2 (+/- 5.84) ($p < 0.001$).

The increase in confidence scores was principally driven by three specific scenarios: pediatric patient, patient with dementia, and mildly intoxicated patient. Participants' mean confidence increased in every scenario except for that of the patient in active labor. In this case, the mean confidence score stayed constant at 9.54 (+/- 1.06) out of 10.

DISCUSSION

In our busy urban system, we found that it was feasible for EMTs and paramedics to complete a simulation exercise with a standardized patient while on shift without significant disruptions in service. Simulation is widely recognized as a valuable educational modality but is often thought of as time intensive. On-shift simulation offers benefits to both clinicians, who can complete training while working their usual schedule, and administrators, since they do not need to pay for extra staff coverage or separate training pay.

Since on-shift simulation is only useful if it achieves the desired educational goal, participants' test scores and confidence levels were tracked as secondary outcomes in this study. Because this was primarily a feasibility study of on-shift simulation and the specific educational content was of secondary importance, we used it as an opportunity to begin the development of tools to improve and evaluate skills in capacity assessment. The specific questions, scenarios, and evaluation tools will require further refinement.

With that in mind, participants were able to correctly determine capacity in a variety of common scenarios on a written test both before and after the educational intervention. Based on our experience in the field and in reviewing medical command calls regarding questions of capacity, we believe that further education and training in capacity assessment are needed. The high pretest scores probably reflect that the test scenarios could be made more difficult in order to find knowledge gaps.

Based on the improvement in confidence scores for particular questions, it is likely that education targeted to specific topic areas regarding capacity would be beneficial. In our service these were pediatrics, dementia, and mild intoxication; topic areas would likely vary between different services, depending on their predominant call types and patient populations.

LIMITATIONS

The most important limitation of this study is that it was a pilot study with a small number of participants. Numerical results should be interpreted with caution appropriate to the small study population. Additionally, participants were principally those who workday shifts since the patient actors were only available during regular daytime work hours.

The fact that the same scenarios were used for the pre- and posttests could also be considered a limitation. Given the nature of this pilot study, it would have been disproportionately difficult to write two different tests while being confident that both assessed the same topic areas at the same level of difficulty. Writing two tests and using a random crossover control model was considered, but the small study size made that statistically impractical. In an attempt to mitigate this potential limitation, participants were not given any feedback about test answers between the pre- and posttest.

CONCLUSION

In this pilot study, EMTs and paramedics working in a busy urban system were able to complete a simulation exercise with a standardized patient while on shift without significant disruptions in service. Participants were able to correctly determine capacity in a variety of common scenarios on a written test, but our educational intervention significantly increased their confidence in their capacity assessments. Further work is needed to apply educational intervention to both day and night shift personnel and to find the appropriate level of difficulty of scenarios in evaluating capacity assessments. On-shift simulation has the potential to be a useful and cost-effective method of providing EMS education in a wide variety of topic areas and settings.

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CASE REPORT

HIGH PRESSURE VENTILATION INJURIES FROM SUPRAGLOTTIC AIRWAY DEVICES: A REPORT OF TWO CASES

Jackson Vescuso BSN, CFRN, C-NPT[1]; Michael Dunn[1]; Cayleigh A. Montaño, CFRN[1]; Fred Jeffries, MS, NR-P[2]; Michael A. Frakes APRN, CCNS, FCCM, FACHE[1]; Jason E. Cohen, DO, FACEP, FCCM[1,3]; Susan R. Wilcox, MD, FACEP, FCCM, FAAEM*[1,4]

Author Affiliations: 1. Boston MedFlight, Bedford, MA, USA; 2. University of Florida; 3. Division of Critical Care Medicine, Department of Emergency Medicine, Brigham and Women's Hospital, Boston, MA, USA; 4. Division of Pulmonary and Critical Care, Lahey Hospital, Burlington, MA, USA.

**Corresponding Author*: susan.r.wilcox@lahey.org

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Keywords: supraglottic airway, supraglottic device, laryngeal mask, pneumothorax, subcutaneous emphysema, emergency medical services, EMS, paramedicine

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ABSTRACT:

Supraglottic airways (SGAs) can be life-saving devices allowing for oxygenation and ventilation, both as a primary airway management technique as well as a rescue device. However, these devices also have a risk of high-pressure ventilation injuries, including pneumothoraces, pneumomediastinum, and massive subcutaneous air. We present two cases of patients with high-pressure ventilation injuries after the placement of SGAs in the prehospital setting. Clinicians should be aware of the risk of high-pressure ventilation injuries with SGAs, especially in older patients, those with a higher BMI, those with preexisting airway trauma, and those with high-pressure ventilation requirements.

INTRODUCTION:

Supraglottic airways (SGAs) are potentially life-saving devices that allow for oxygenation and ventilation. These devices are invaluable as rescue airway devices in patients who cannot otherwise be intubated (Apfelbaum et al., 2022; Gordon et al., 2018). Additionally, SGAs are increasingly used in primary airway management in the out-of-hospital setting, especially in cases of cardiac arrest (Benger et al., 2020; Lee et al., 2022). However, these devices have risks. In addition to the well-known risks of aspiration and ineffective ventilation (Gordon et al., 2018; Simon & Torp, 2022), clinicians should be aware of the risk of high-pressure ventilation injuries, including pneumothoraces, pneumomediastinum, and massive subcutaneous air (Muszalski et al., 2019). Although rare, this is a known complication of SGA placement. Here, we present two cases of patients with high-pressure ventilation injuries after the placement of SGAs in the prehospital setting.

CASE 1:

An 85-year-old man with a history of colon and pancreatic cancer, as well as atrial fibrillation on Plavix, presented to the emergency department after a fall. On the day of presentation, the patient cried out at home, collapsed, and fell down an unknown number of stairs. He sustained obvious head and facial trauma. His family called emergency medical services (EMS), and on their arrival, they attempted to intubate the patient. After two unsuccessful attempts, the paramedics noted blood in the airway. Therefore, intubation attempts were aborted, and a King supraglottic airway (SGA) was placed. Upon arrival to the emergency department (ED) he was noted to have extensive subcutaneous air in the neck and face. On chest radiograph (Figure 1) the patient had bilateral pneumothoraces and subcutaneous air.

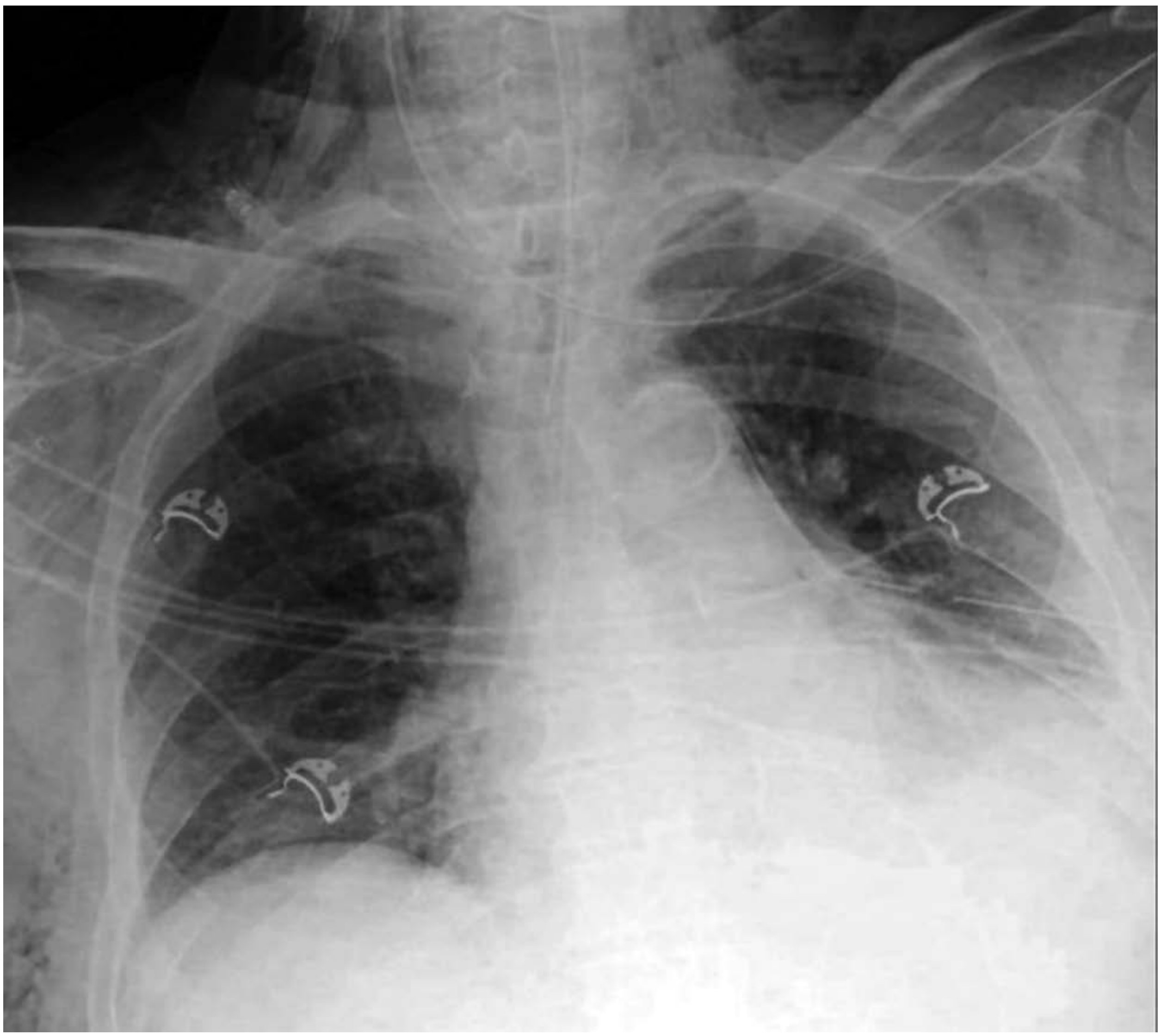

Figure 1. Chest radiograph after intubation and placement of a left sided chest tube demonstrating massive subcutaneous emphysema in the chest and neck.

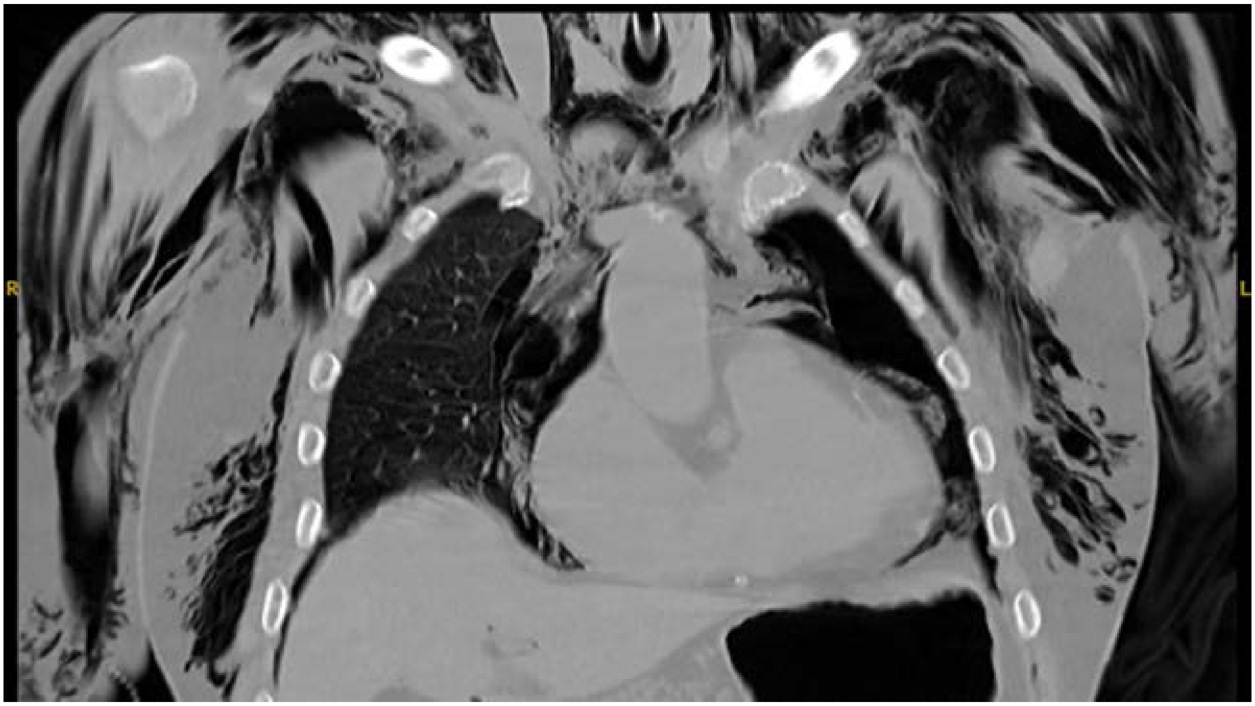

Figure 2. Computed tomography highlighting the massive subcutaneous emphysema and a residual anterior left pneumothorax.

The ED team promptly placed bilateral chest tubes for thoracic decompression. He was then intubated on first attempt by the ED team with videolaryngoscopy after blood was suctioned from the airway. He had non-contrast computed tomography (CT) showing bilateral pneumothoraces, pneumomediastinum, pneumocardium (Figure 2), and pneumoperitoneum as well as an intracranial 3 cm bleed vs mass to the left basal ganglia with mass effect.

The critical care transport (CCT) team was contacted for transport to a tertiary care center for surgical evaluation. The CCT team arrived to find the patient intubated with diminished bilateral breath sounds but symmetrical chest expansion. He had extensive subcutaneous air to the face, neck, and chest, despite his bilateral chest tubes being placed to suction. His ventilator was set with pressure control ventilation, with an inspiratory pressure of 15 cmH_2O, a positive end expiratory pressure (PEEP) of 5 cmH_2O, with resultant tidal volumes (TV) of 400 mL, a rate of 16 breaths per minute, a fraction of inspired oxygen (FiO_2) of 30%. His oxygen saturation was 100%. His chest tubes were maintained on 20 cmH_2O of suction, and he was transported uneventfully.

CASE 2:

An 84-year-old woman with a past medical history of hypertension, hyperlipidemia, acid reflux, and previous stroke was found unconscious in her nursing home. The patient was noted to have diarrhea the day prior. The nursing home staff called 911, and the EMS team arrived to find the patient with agonal breathing and a systolic blood pressure of 80 mmHg. The paramedics attempted to intubate, obtaining a Grade 1 view but unable to pass the endotracheal tube. They therefore placed a laryngeal mask airway (LMA). After attempting to ventilate the patient through the LMA, the EMS team noted substantial swelling developing over the patient's chest, neck, and face. They were concerned this rapid swelling was an allergic reaction. The patient was then rapidly transported to a local emergency department.

In the ED the swelling was believed to be subcutaneous emphysema, and the ED staff replaced the LMA with an endotracheal tube. A chest radiograph demonstrated bilateral tension pneumothoraces, resulting in her hypotension, along with massive subcutaneous air (Figure 3).

The ED team then placed bilateral chest tubes with rushes of air. Despite improvement in her profound hypotension from the bilateral thoracostomies, the patient remained hypotensive. She was started on norepinephrine at 7.5 mcg/min, and the CCT team was called for transport to tertiary care.

The CCT team arrived to find an older woman intubated on the stretcher with clear and equal lung sounds bilaterally. They noted subcutaneous air diffusely throughout her upper chest, neck, and face. The bilateral chest tubes were connected to wall suction without any bubbling or tidaling noted. The chest radiograph confirmed chest tube placement with a slightly shallow drain port in subcutaneous tissue (Figure 4).

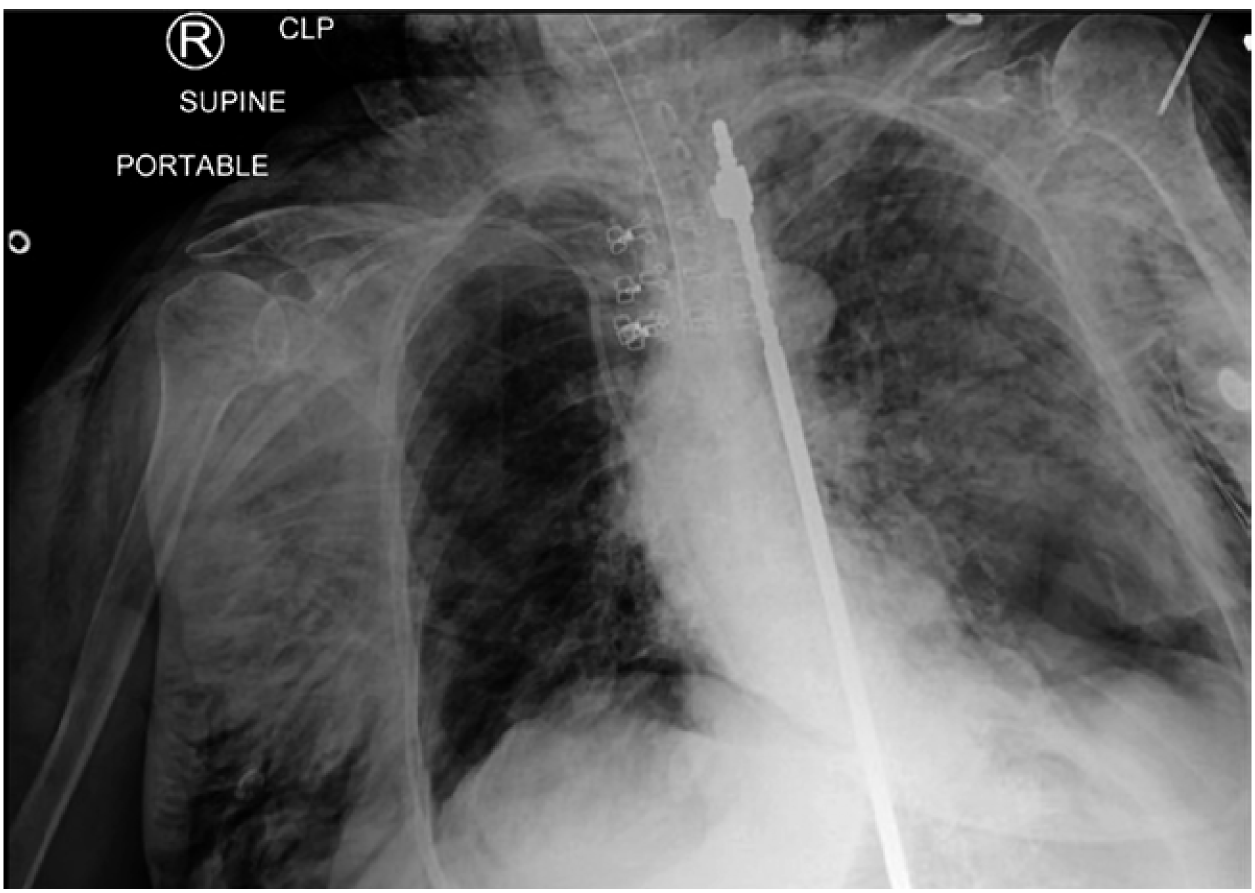

Figure 3. Chest radiograph demonstrating bilateral pneumothoraces with tension, resulting in a compressed mediastinum, and massive subcutaneous emphysema.

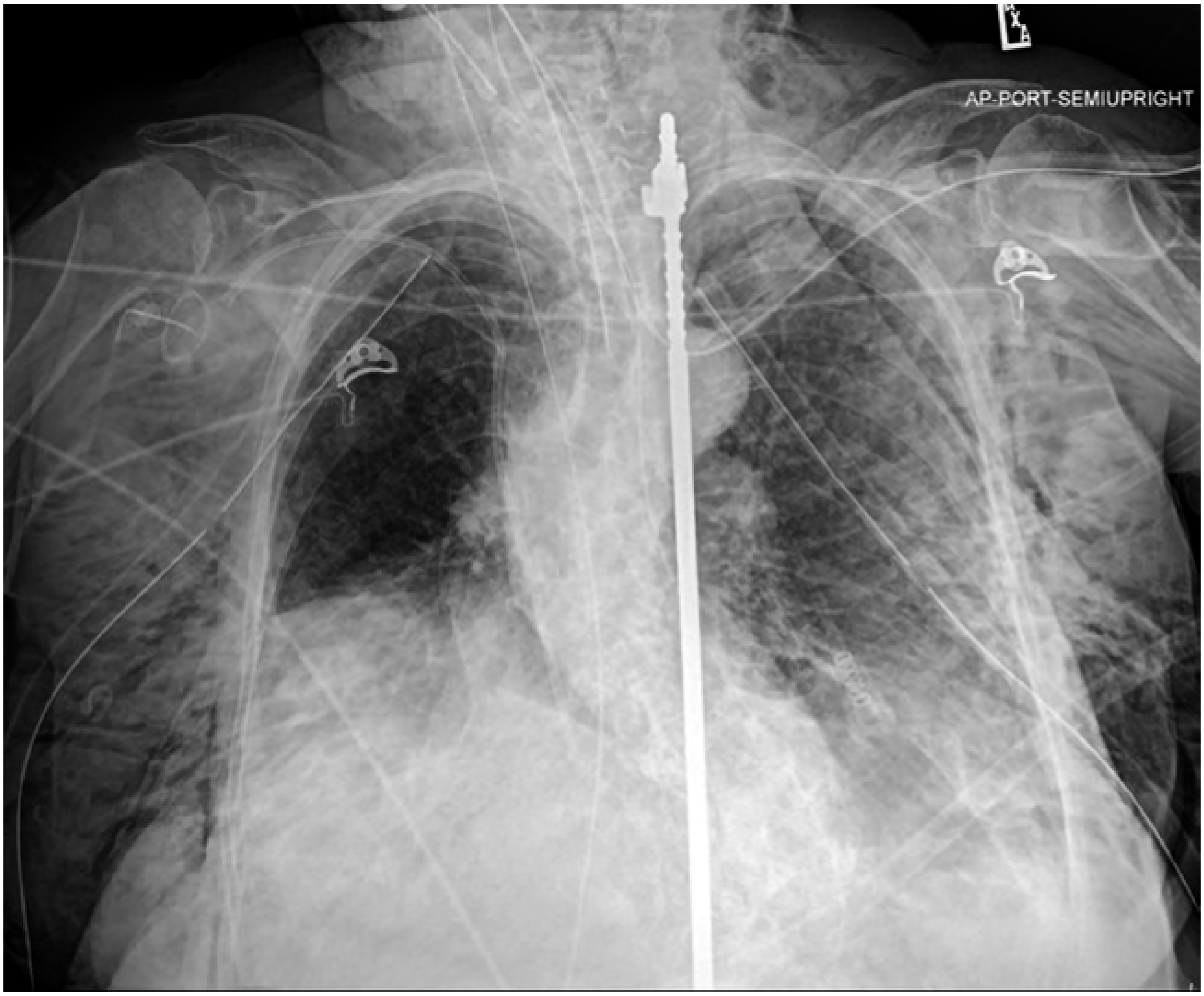

Figure 4. Chest radiograph after placement of bilateral chest tubes and persistent subcutaneous emphysema of the chest and neck.

Her vitals were notable for an oxygen saturation of 82% with a nadir of 79% while awaiting transport. She was ventilated with volume control ventilation with TV of 300 mL, a rate of 28 breaths per minute, a PEEP of 3, and FiO_2 90%. With these settings and the chest tube drainage, her peak inspiratory pressure was only 19 mmHg. The CCT team continued the same ventilator settings and with her chest tubes to suction. She was transported safely to a tertiary care center for surgical evaluation.

DISCUSSION:

Supraglottic airways (SGAs) are an important instrument in airway management. In both the cases presented, the SGA served as a life-saving instrument in patients who could not otherwise be intubated. However, both patients suffered adverse events, likely related to the placement of the SGA. Once predominantly used in the operating room, over the last 30 years SGAs have been increasingly used in the prehospital setting (Gordon et al., 2018; McNarry & Patel, 2017; Simon & Torp, 2022). The SGA allows for oxygenation and ventilation with blind placement just superior to the glottic opening (Simon & Torp, 2022), and they can be placed quickly and easily without the use of a laryngoscope. In addition to serving as a rescue device, SGAs are increasingly used in out of hospital cardiac arrest. Literature has shown a decreased time to placement as compared to intubation, with no decrement in clinical outcomes (Benger et al., 2020; Lee et al., 2022; Tjerkaski et al., 2022).

This ease of placement can also be beneficial in situations where there have been multiple attempts to place an endotracheal tube (ETT) without success (Gordon et al., 2018; Heidegger, 2021). SGAs are recommended as a rescue device in the 2022 American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway (Apfelbaum et al., 2022). In both of the cases reported, the EMS team encountered a patient in the field who required intubation but could not be intubated by a direct laryngoscopy approach. In both cases, the use of the SGA may have been lifesaving to provide oxygenation and ventilation, although both patients also sustained untoward effects.

Despite the ease of placement and the common use, SGAs have inherent risks. Since the insertion of the SGAs is largely blind, there are risks of oropharyngeal trauma, bleeding, swelling, and infection (Gordon et al., 2018). The position does not create a seal to protect the airway and lungs, as is found in endotracheal intubation. While the risk of aspiration and gastric inflation with SGAs are well-reported (Gordon et al., 2018; Simon & Torp, 2022), the risks of pneumothorax, pneumomediastinum, and subcutaneous emphysema are known, but are less well-established. By placing this device superior to the glottic opening, the airway pressures needed to ventilate the patient can also be applied to structures that normally are not exposed to positive pressure. This can cause air to be forced into the tissues, especially in the setting of difficult ventilation requiring higher airway pressures. The existing literature does not report massive subcutaneous air with prehospital primary SGA placement; the only reports are with SGA placement after failed intubation attempts, consistent with the present cases. However, there are reports of SGA-associated pneumothoraces and pneumomediastinum in the peri-operative literature (Choy & Pescod, 2007; Gianesello et al., 2019; Michalek et al., 2015). While the patient populations differ, these reports support the recognition of pressure ventilation injures with SGA use.

The risk of subcutaneous air secondary to SGA placement is known to be higher in patients with a higher body mass index (BMI), those who are older than age 46 (Michalek et al., 2015), previous laryngoscopy attempts that have caused trauma (Michalek et al., 2015), and ventilating with high airway pressures (Atalay et al., 2015), In both of the cases presented, the patients were of older age and had unsuccessful laryngoscopy attempts with trauma. Our transport group previously published a case of a 52-year-old woman with a high BMI and oral trauma from a seizure who developed massive subcutaneous emphysema after placement of a King LT (Ambu Inc., Columbia, MD) supraglottic device (Muszalski et al., 2019). Similarly, this previously reported patient had several of the risk factors for subcutaneous emphysema after an SGA placement. Existing case reports implicate both the laryngeal mask airway and King LT. It is unknown whether the risks of high-pressure ventilation injuries differ among the various SGA devices.

To alleviate subcutaneous air, small incisions can be made into the skin just inferior to the clavicles (Johnson et al., 2014). Alternatively, angiocatheters may be inserted into the subcutaneous space to allow air to escape, although restoration of anatomic landmarks will take some time. If air has migrated into the pleural space resulting in pneumothorax, the patient will likely require a tube thoracostomy. Pneumomediastinum is usually treated conservatively with pain control, administration of 100% oxygen, and monitoring (Kouritas et al., 2015).

Clinicians need to be aware of the risks of massive subcutaneous air secondary to SGA placement as it can be a lethal complication for their patient. Massive subcutaneous air can distort airway anatomy leading to the inability to place any airway device. Air in the chest, either as a tension pneumothorax or massive pneumomediastinum, can put pressure on the great vessels and lead to obstructive shock. Additionally, subcutaneous swelling can be mistaken for an allergic reaction, as it was in the second case reported here. Recognition of the actual etiology of swelling is essential to provide the appropriate interventions. Awareness of the potential complications may not only mitigate the risks of these complications but also lead to quicker reaction if they occur.

CONCLUSION:

SGAs are lifesaving devices and are indicated for patients who cannot be intubated. Although the risks of aspiration and ineffective ventilation are known, the risks of high-pressure ventilation injures have been underappreciated. Clinicians should be aware of this risk, especially in older patients, those with a higher BMI, those with preexisting airway trauma, and those with high pressure ventilation requirements. These risks should not preclude the use of SGAs, but awareness of the issue will result in improved understanding and prompt management when they occur.

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CASE REPORT

SERIAL ELECTROCARDIOGRAMS SHOW ACUTE ONSET OF INVERTED P WAVES IN A 62-YEAR-OLD MALE WITH CHEST PAIN: A CASE REPORT

Brenton Faber, PhD, NREMT*[1]

Author Affiliations: 1. Professor, Worcester Polytechnic Institute, Worcester, MA; Paramedic, Potsdam Volunteer Rescue Squad, Potsdam, NY, USA.

**Corresponding Author*: bdfaber@wpi.edu

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ABSTRACT

Iatrogenic events are common causes of EMS encounters. This report present the case of a 62-year-old male who presented with new-onset chest pain after his primary care provider increased his diltiazem dose to better control atrial fibrillation. The patient presented with nausea, vomiting, diaphoresis, and 8/10 sub-sternal chest pain. Sequential ECGs captured the initiation of a junctional rhythm indicated by negative (inverted) P waves and a shortened PR interval. The patient had also been prescribed dofetilide (Tikosyn), which can raise diltiazem levels. The case emphasizes the importance of recognizing arrhythmias associated with retrograde A/V conduction and raises awareness of potential iatrogenic events as causes for prehospital encounters.

INTRODUCTION

Iatrogenic events, defined as harm resulting from the actions of healthcare providers, are common reasons for emergency medicine encounters (Peer & Shabir, 2018). Schwendimann et al. (2018) found that up to 10% of hospital inpatients have experienced at least one iatrogenic event, with half preventable and 7.3% fatal. In their study of admissions to 11 Massachusetts hospitals, Bates, Levine, and Salmasian (2023) found that adverse events occurred in 23.6% of admissions, and 32.3% of these events caused harm that required intervention or recovery.

Medication errors are a common and often serious cause of patient harm (Baumgartner et al., 2018; Wittich et al., 2014; Kohn et al., 2000). Simpson and Kovach (2021), in a retrospective study of 126 older patients in a post-acute rehabilitation center, found that of 578 new reported problems, 41.7% were iatrogenic adverse events, and medication-related events were common. Insani, Whittlesea, Alwafi, et al. (2021), in their systematic review of adverse drug reactions

(ADR) in primary care, found a pooled prevalence of 8.32%, with cardiovascular system drugs being the most commonly reported medication class. Similarly, Wong, Lee, Sarkar, and Sharma (2022), in their study characterizing ambulatory-care-related adverse events, found that the largest group of events were medication-related (17%). Sheikh & Bates (2014) report that pediatric and geriatric patients, as well as patients who are physiologically compromised, have complex underlying medical conditions, and have behavioral health issues are at greatest risk for iatrogenic events.

This case report presents a prehospital encounter wherein an increase in a patient's daily diltiazem dose resulted in the acute development of an accelerated junctional rhythm. As we show below, the change in conduction was captured by serial prehospital ECGs. The case emphasizes the importance of recognizing the arrhythmias associated with retrograde A/V conduction, maintaining a high index of suspicion for potentially iatrogenic reasons for patient complaints, and conducting serial ECGs in acute onset chest pain. Patient identifiers have been changed or redacted from the case.

CASE REPORT

A 65-year-old male called 911 for new onset sub-sternal chest pain, shortness of breath, nausea, and diaphoresis. He had a history of atrial fibrillation and hypertension and his medications included pantoprazole for GERD, hydrochlorothiazide and lisinopril for hypertension, and dofetilide and diltiazem (Cardizem) for atrial fibrillation. He had no history of myocardial infarction. The 911 dispatcher advised the patient to take 325 mg of aspirin. A few hours before this event, his primary care provider increased his daily diltiazem dose from 180mg to 240mg to better control his atrial fibrillation.

CLINICAL FINDINGS

On EMS arrival, the patient appeared anxious. He was alert and oriented, had a GCS of 15, and could answer questions appropriately and in full sentences. He stated that he began to feel his symptoms approximately one hour ago and was now experiencing 8/10 chest pain. The pain was continuous, increased with exertion, and was associated with increased work of breathing.

He had regular radial pulses with a heart rate of 72 and a blood pressure of 120/75 mmHg (MAP 90). His lungs sounds were clear bilaterally with a respiratory rate of 16 breaths per minute and an SpO2 of 97% on room air. The patient did not use oxygen at home. His temperature was 96.7 F. His blood glucose was 104 mg/dL.

The first of three 12-lead ECGs, recorded before the ambulance left the scene (Figure 1), showed a normal sinus rhythm, a premature ventricular complex (PVC), and slight straightening of the ST segment in V2 and V3 but no ST elevations greater than 1 mm. A second ECG recorded 6 minutes later (Figure 2) showed a regular rhythm at 68 bpm and negative (inverted) P waves. The PR interval was shortened to 108 ms (normal 120-200 ms), and the QRS duration was 107 ms. The ST straightening in V2 and V3 was resolved, and no leads showed ST elevation greater than 1 mm. A third ECG recorded

13 minutes later (Figure 3) showed a regular rhythm with a rate of 71 bpm, negative P waves, and a PVC. The PR interval remained short at 112 ms, and the QRS duration was 106 ms.

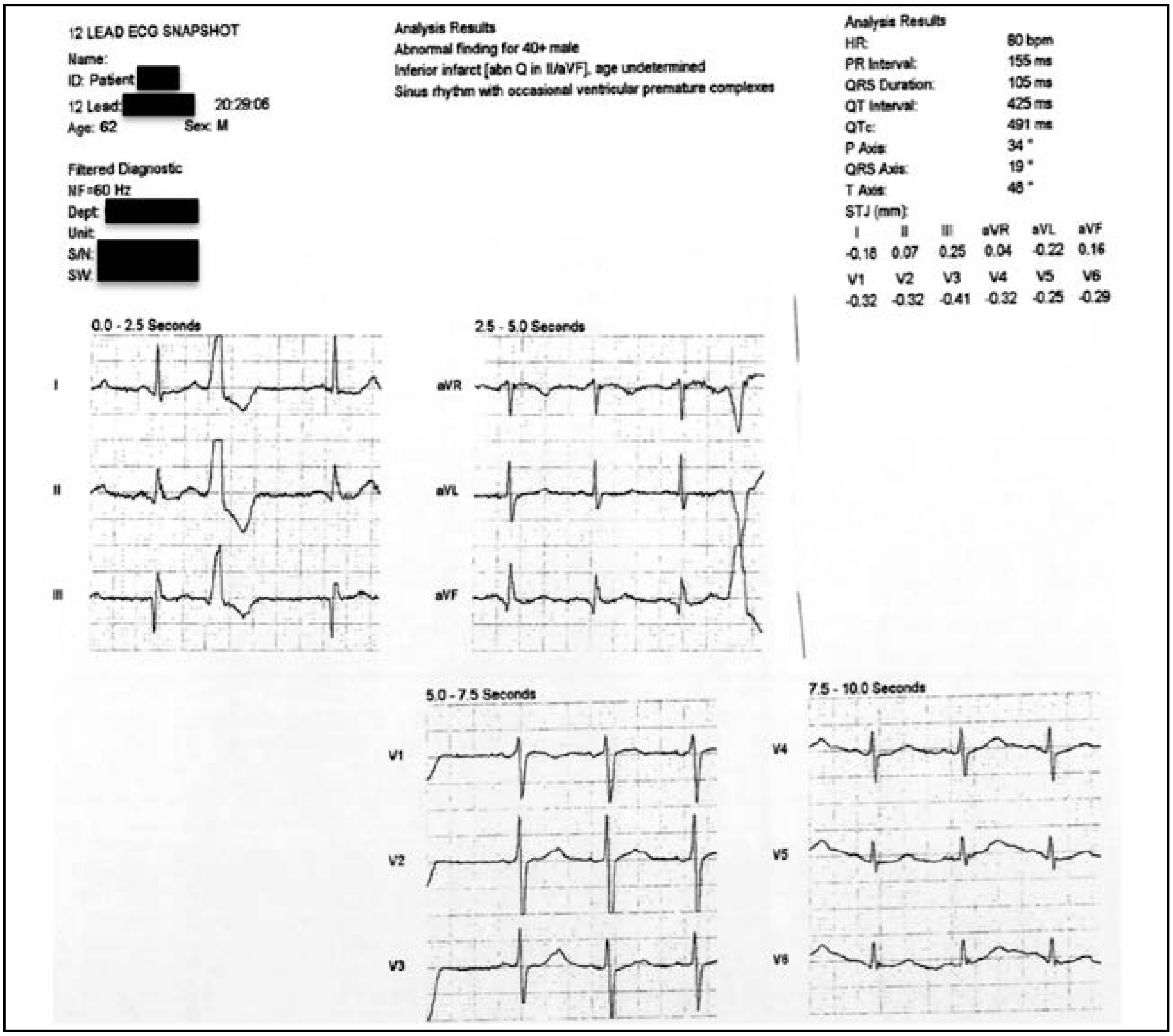

Figure 1. Twelve-lead electrocardiogram #1 performed at 20:29. The EKG shows a normal sinus rhythm with a rate of 80 bpm. The PR interval is 155 ms (normal range 120-200 ms). The QRS complex is normal, if slightly extended, in duration at 105 ms (normal range 70-100 ms). There is a premature ventricular complex (PVC).

The patient remained anxious throughout the encounter, and his GCS remained 15. Repeated vitals recorded blood pressures of 123/84 mmHg (MAP 97) and 131/85 mmHg (MAP 87). His SpO2 remained 96% on room air, and his respiratory rate remained 16 breaths per minute. His chest pain remained unchanged.

He was treated prehospitally with 4 mg of ondansetron IM and 250 ml of intravenous normal saline, and patient care was transferred to the Emergency Department (ED) of a rural community hospital. The ED course was uneventful, and all the patient's labs returned normal. The initial hospital EKG also showed a junctional rhythm. The patient converted to a normal sinus rhythm after several hours. After 3.5 hours, the patient was discharged to home. The discharge diagnosis was atypical chest pain. It was determined that the increased diltiazem dose had slowed atrial conduction and instigated a junctional rhythm. The hospital's cardiology department recommended reducing the diltiazem dose back to 180 mg daily.

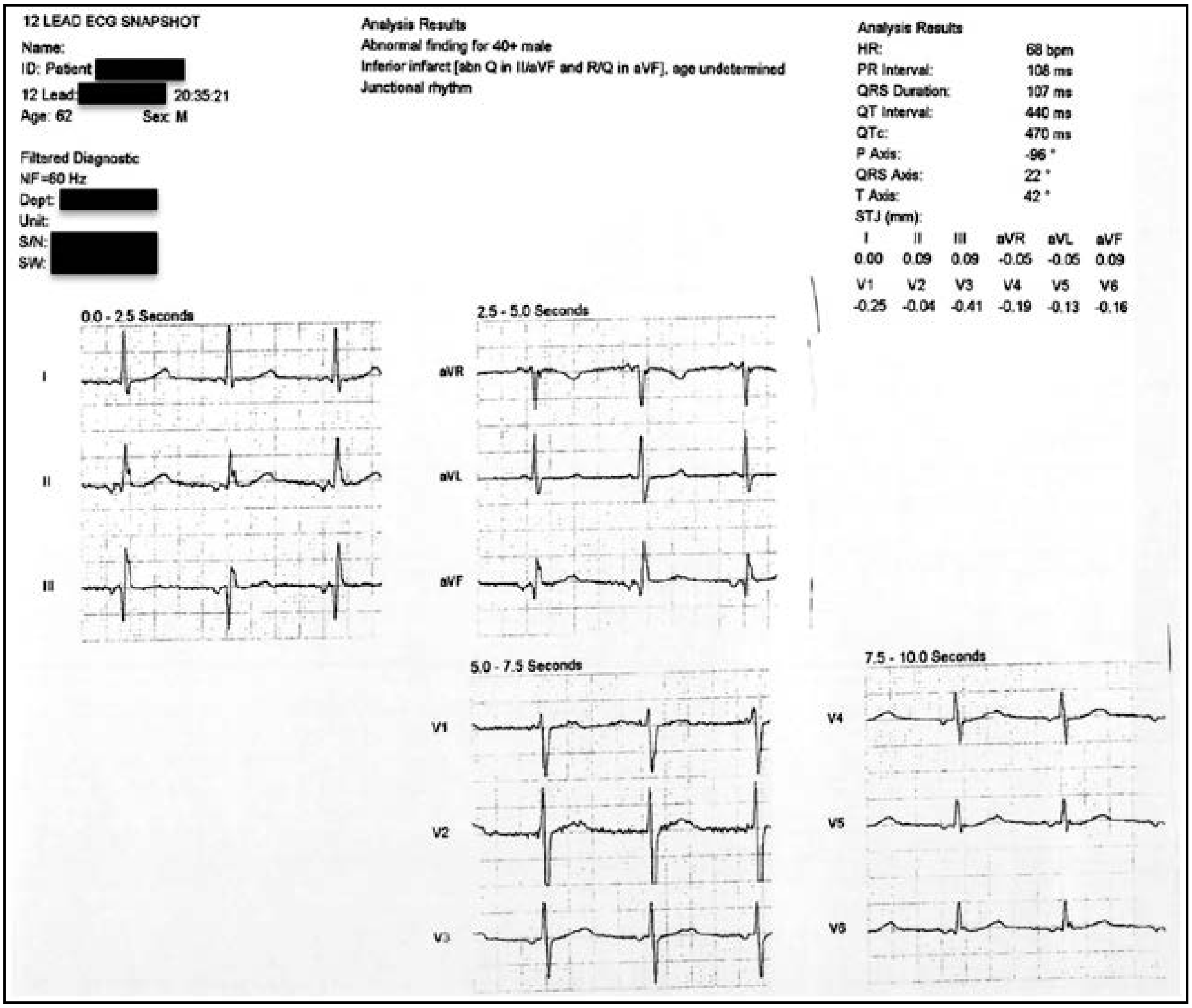

Figure 2. Twelve lead electrocardiogram #2 performed at 20:35. The second 12-lead EKG shows a regular rhythm at 68 bpm. P-waves are now negative (inverted) and the PR interval is shortened to 108 ms. The QRS duration is 107 ms. No leads show ST elevation greater than 1 mm.

DISCUSSION

The heart's electrical conduction system normally initiates an electrical stimulus at the sinoatrial (SA) node. This electrical stimulus traverses through the atria to the atrioventricular (AV) node, where it is briefly slowed before continuing to the ventricles via the

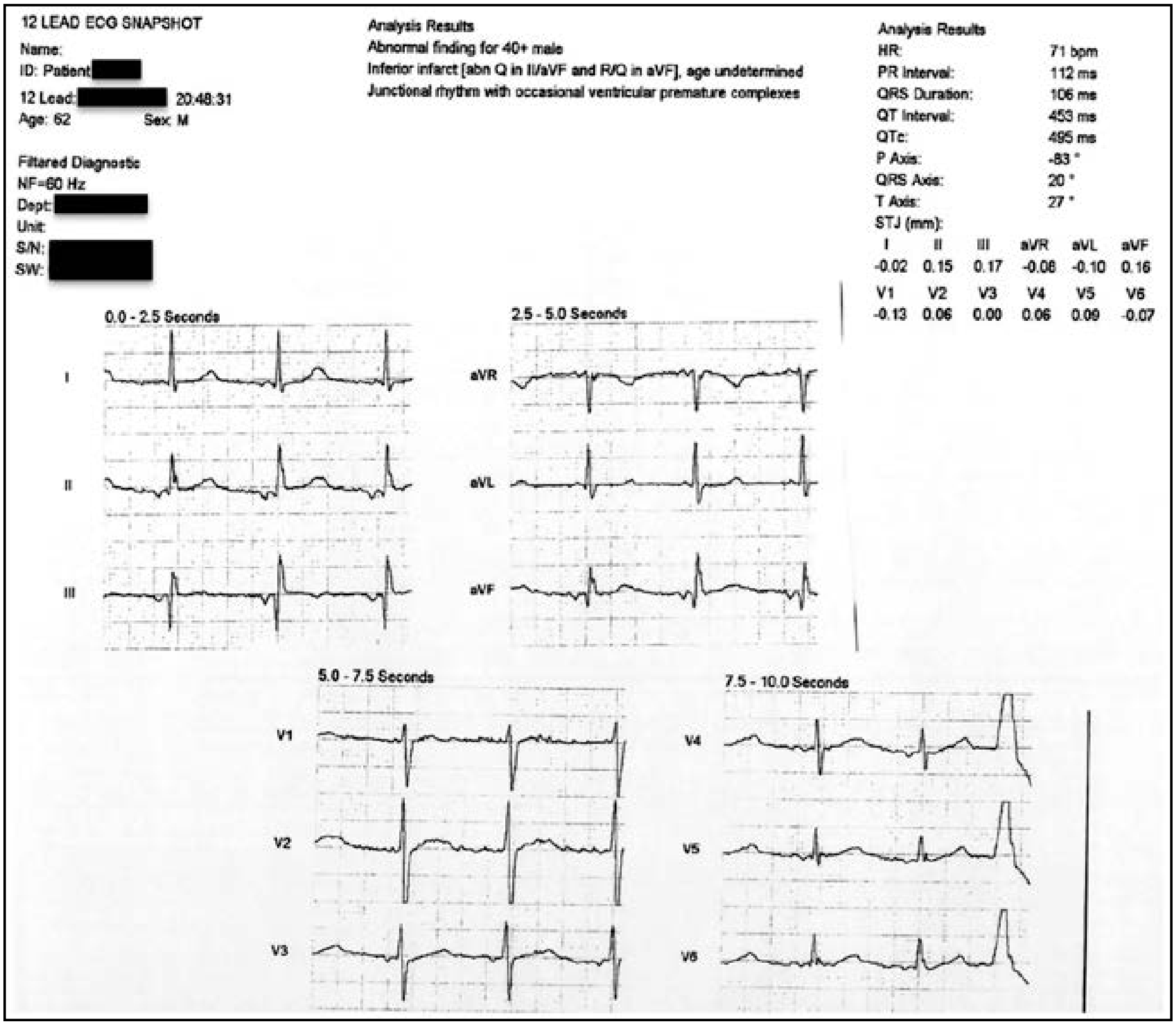

Figure 3. Twelve lead electrocardiogram #3 performed at 20:48. The third 12-lead EKG shows a regular rhythm with a PVC at a rate of 71 bpm. P-waves remain negative (inverted) and the PR interval remains short at 112 ms. The QRS duration is 106 ms. No leads show ST elevation greater than 1 mm.

bundle of HIS, where it diverges into the left and right bundle branches of the ventricles.

The AV node filters impulses from the atria, enabling regular and optimum conduction to the ventricles (Billette & Tadros, 2019). The more frequently the AV node is stimulated, the slower the node conducts an impulse (Fogoros, 2022). This feature provides natural protection from diseases like atrial fibrillation (AF), which can conduct hundreds of impulses per minute to the AV node (Fogoros, 2022).

If the SA node is damaged or blocked, the AV node, the bundle of HIS, or a site low in the atria can take over as the heart's primary pacemaker (Grauer, 2019;

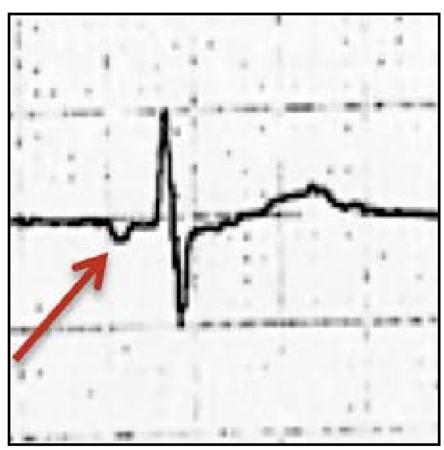

Figure 4. Negative (inverted) P-wave (red arrow)

Hafeez & Grossman, 2022). The AV node can conduct electrical impulses bidirectionally (Adams & Pelter, 2004). If the SA node fails to depolarize (activate) the atria, the AV node can take over and initiate what is called retrograde conduction (Adams & Pelter, 2004). Retrograde conduction will appear as negative (inverted) P waves in an EKG tracing (Figure 4) and a shortened PR interval (less than 120 ms). In some cases, the inverted P waves may be found after the QRS. In these patients, atrial depolarization occurs after ventricular depolarization, and there is no atrial-ventricle synchronicity (Adams & Pelter, 2004).

Junctional rhythms are not rate-dependent but are described as junctional bradycardia (<40 bpm), junctional escape rhythm (40-60 bpm), accelerated junctional (60 to 100 bpm), and junctional tachycardia (>100 bpm) (Burns & Buttner, 2021). A junctional rhythm may also be indicated if the PR interval is less than 120 ms. A reduced PR interval may also suggest accessory pathways between the atria and ventricles or a low atrial rhythm (Grauer, 2019).

Diltiazem (Cardizem) is a commonly used calcium channel blocker prescribed for rate control in patients with AF (Jafri et al., 2021). Diltiazem is used interchangeably with metoprolol, a non-selective beta blocker, depending on physician preference, availability, and patient responsiveness (Jafri et al., 2021). Diltiazem acts by slowing conduction between the SA and AV nodes, reducing the electrical stimulation in atrial cardiac tissue associated with AF (Jafri et al., 2021). Diltiazem also inhibits cardiac and smooth muscle contractions and increases vasodilation in coronary and systemic arteries (Jafri et al., 2021; Morrow & de Lemos, 2019). Side effects are associated with vasodilation and are typically seen at dosages exceeding 240mg daily (Morrow & de Lemos, 2019).

The patient was also prescribed dofetilide (Tikosyn), a class III antiarrhythmic agent prescribed for atrial fibrillation or flutter. Dofelitide can raise diltiazem levels (Epocrates). By blocking potassium channels, Dofelitide slows repolarization and increases the refractory period of atrial tissue (Ibrahim, Kerndt, & Tivakaran, 2023).

While this patient's condition was attributed to the increase in his diltiazem prescription, digitalis toxicity is the classic cause of accelerated junctional rhythms (Burns & Buttner, 2021). Other causes of junctional rhythms include cardiac surgery or acute myocardial ischemia.

Fortunately, this patient remained stable throughout the encounter. Had the patient's condition deteriorated, unstable calcium channel overdose treatment focuses on airway, breathing, and circulation. Chakraborty and Hamilton (2023) recommend continuous cardiac monitoring and IV crystalloids during initial resuscitation, and they suggest considering endotracheal intubation for rapidly deteriorating patients with hemodynamic compromise. They note that providers should watch for fluid overload if the patient experiences cardiac slowing or weak contractions due to the drug's negative inotropic effects. Pharmacological therapies for unstable patients can include calcium, insulin, glucagon, and catecholamines (dopamine, norepinephrine, epinephrine) to improve vascular resistance and hypotension (Levine, 2018). As always, work within local protocols and consult medical control or poison control centers when needed.

CONCLUSION

The presence of inverted P waves and a shortened PR interval (< 120 ms) indicate a junctional or low-atrial rhythm. Absent congenital issues, recognition of an accelerated junctional rhythm should prompt suspicion of digitalis toxicity or iatrogenic causes. Other causes of junctional rhythms include calcium channel blocker toxicity, ischemia or infarction, and recent cardiac surgery. The case also raises awareness of iatrogenic events, such as prescription drug complications, as causes of prehospital encounters. Finally, the case reminds us that serial ECGs should be a regular part of any chest pain work-up in the field.

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International Journal of Paramedicine

Published by the National EMS Management Association (USA)

GUIDELINES FOR AUTHORS

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 National Association of EMS Physicians in support of *Prehospital Emergency Care*. In continuation of that relationship, IJOP and PEC have established a collaborative relationship that will the facilitate the exchange of submissions in certain circumstances based in part on which journal may be the best fit for a particular manuscript.

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)

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.

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:

The submission cannot be previously published or in the submission process of another publication (or an explanation has been provided a cover letter to the Editor).

The Author and Funding File and the Main Submission File are both in Microsoft Word document file format.

An ICMJE Form for Disclosure of Potential Conflicts of Interest is submitted for each author.

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.

The text is double-spaced in a 12-point font.

Page numbers and line numbering is used for the 'Main Submission File'

The text adheres to the stylistic and bibliographic requirements outlined.

Authors are strongly encouraged to follow any EQUATOR (Enhancing the QUAlity and Transparency Of health Research) Guidelines that apply to their type of research. These include, but are not limited to:

- 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
- PRISMA 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/prognostic studies
  - STARD and the TRIPOD extension
    - https://www.equator-network.org/reporting-guidelines/stard/
- 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/care/
- 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/
- Economic evaluations
  - CHEERS
    - https://www.equator-network.org/reporting-guidelines/cheers/

Note that there is a section in EQUATOR with guidelines specific to emergency medicine that may also be applicable to studies in paramedicine.

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.

Author and Funding Information File

Author page

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.

The email of all authors should also be included.

If available, please include ORCiDs (http://orcid.org) numbers for each author.

You also include social media handles (e.g., Facebook, Twitter, LinkedIn) for each author.

Please ensure that everyone who meets the International Committee of Medical Journal Editors (ICMJE) requirements for authorship is included as an author (http://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html).

If an author changes their affiliation during the peer-review process, the new affiliation information can be given to the Editorial Team and will be handled as any other manuscript revision. Please note that no changes to affiliation can be made after the pre-publication galleys of the manuscript have been accepted for final publication.

Identify one author as the corresponding author. They will be shown as such when the article is published and will be the point of contact between the editorial team and the authors.

If the work presented in the manuscript was presented at conference or published in abstract form, identify the name of the event, location, format, and date of presentation.

Acknowledgements, where applicable, can be provided. Brevity is strongly encouraged.

Funding

Please provide the details for any funding that supported the submitted work, to include all details required by your funding and grant-awarding bodies. The following template sentences are suggested:

- For single agency grants: This work was supported by the [Funding Agency] under Grant [number xxxx].
- For multiple agency grants: This work was supported by the [Funding Agency #1] under Grant [number xxxx]; [Funding Agency #2] under Grant [number xxxx]; and [Funding Agency #3] under Grant [number xxxx].
- If a funding source was not involved, please confirm with a statement such as, "External funding was not used to support this work."

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 identifies 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 should include removal of identifying information in the 'properties' of the Microsoft Word (.doc or .docx) files that are submitted.

Unless stated otherwise in the directions for a specific manuscript category, all submissions should include the following elements in the following order as a single document file, called the Main Document File.

Title

Provide the suggested title for the published article. Please note that the title used for publication is subject to editorial team approval.

Abstract, Keywords, Disclosures / Conflicts, Presentations, and Acknowledgements

Unless exempted or described differently in the directions for a specific submission category, abstracts MUST be limited to 300 words or less, including the section headers (e.g., Problem, Methods, etc.).

Unless exempted or described differently in the directions for a specific submission category, this page will also include between three (3) and six (6) keywords or short phrases that will be used for title and search engine optimization. Keywords of 'paramedicine' and 'emergency medical services' will be added by default and will not count towards the keyword count requirements.

State any disclosures or conflicts for each author. This will be in addition to completion of the ICMJE Disclosure Forms for each author as described below. If the are no conlficts, please state 'none.'

Primary Manuscript Body

The primary body of the manuscript will come next in the main submission file. The composition of the primary body of the manuscript may vary with the category of the manuscript. Refer to specific manuscript category descriptions for details.

The manuscript should use a minimum of formatting. If there are multiple levels of heading and sub-headings, please indicate the heading level by placing (H1) directly after the heading text for the top level heading, H2 for sub-headings, H3 for sub-sub headings, etc.

Tables should be used to summarize large amounts of information rather than writing it out as a narrative. Tables may be created within the word processor or inserted from another program (e.g., Excel). If another program is used to create the table, please include the original source file as a supplementation media file submission. All tables should be inserted into this primary manuscript body file. They must be labelled sequentially, and referred to in the text. Table captions must include the table number and a name for the table at a minimum. Additional descriptive text may be added to the caption as needed to complement the reference to the table in the main body of the paper.

Figures shall be inserted directly into the text at the appropriate position. These may be lower resolution images to simply show their correct placement. Figures must be labelled sequentially and referred to in the text. Figure captions must be included with the figure number and a name for the figure at a minimum. Additional descriptive text may be added to the caption as needed to complement the reference to the figure in the main body of the paper. In addition to including figures in the text, submit each figure as a supplemental media files in high resolution PDF, .jpeg, .tiff, or .png file formats, with a 300dpi minimum resolution.

References

Where applicable, the references for the manuscript come next. Use endnotes rather than footnotes. The APA style for reference marks and endnotes must be used.

In each endnote, include hyperlink whenever possible to the referenced document. A DOI hyperlink is preferred, which will have a format of https://doi.org/XXXXX. If a DOI is not available, provide a link to the source journal, publisher website or similar source.

Authors are responsible for the accuracy of all references, links and in text citations.

Appendices

Where applicable, any appendices to the manuscript are inserted next.

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

If the submission includes any supplemental tables or figures, they would be each be uploaded individually for inclusion at the end of the article.

For speadsheets used to generate tables, upload them as individual files and clearly indicate which table they are associated with,.

If there are any supplemental media files (e.g., spreadsheets, slide decks, audio or video files), provide links to where readers can access them. They 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 describes its practical application. If the paper presents a new concept, it may also suggest research, improvement projects, or pilot implementations of its application. Along with other standard submission file elements, the primary manuscript body pages file for Concept papers should contain:

- Introduction - The introduction should describe the problem, issue, or circumstance that the concept is intended to address. Where applicable, 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. Where applicable, provide sufficient detail and clarity of any methods or procedures and the setting and population to which the concept applies.
- Discussion - Authors are encouraged to include a critical review of related research and a fulsome discussion that highlights how the concept contributes to the field of paramedicine. Address any limitations of the concept.

Dialogues (≤1,000 words)

The Dialogues section will publish comments and questions from readers related to previously published articles. Along with other standard submission file elements, the primary manuscript body pages file for correspondence 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 point(s) 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. The paper should also discuss any issues to consider in its practical application. Along with other standard submission file elements, the primary manuscript body pages file for Education papers should contain:

- Introduction - The introduction should describe the problem, issue, or circumstance that the educational process, approach, or method is intended to address. Where applicable, address the current literature that demonstrates a gap and any pertinent background information.
- Description – Provide a description of the educational process, approach, or method and how it can be applied. Where applicable, provide sufficient detail and clarity of any methods or procedures and the setting and population to which the process, approach or method applies.
- Discussion - Authors are encouraged to include a critical review of related research and a fulsome discussion that highlights how the concept contributes to the field of paramedicine. Address any limitations of the concept.

Empirical Investigations / Original Research (≤4,500 words)

The submission of manuscripts for empirical investigations / original research may be clinical or non-clinical. Several of the EQUATOR guidelines, described previously, may apply to any given study in this category. Please apply them as appropriate to your particular investigation.

Authors may provide, or editors may suggest, that some information be provided as a supplemental file so that the main paper remains concise. The supplemental content may include data sets, images, video clips, and in-depth details on methodology. Along with other standard submission file elements, the primary manuscript body pages file for empirical investigations / original research should include elements as called for in the applicable EQUATOR guidelines.

NEMSMA is a longtime collaborator with 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 exchanges manuscripts in certain circumstances. Empirical investigations on clinical topics may be forwarded to *PEC* for their initial consideration with author consent.

Methodology (≤2,000 words)

This category of submissions provides deep explorations of methods used or may be used in research studies or improvement projects. These methods should be novel in some way that makes them of significant interest in their own right, separate from the studies in which they are utilized. These papers can also provide a more detailed description of the methods than would otherwise be appropriate in the primary research or improvement project manuscript. The primary paper's methods section may direct readers to a methodology paper in this category for more detailed descriptions of the methods it utilized.

Along with other standard submission file elements, the primary manuscript body pages file for Methodology papers should contain appropriate elements from the EQUATOR guidelines, as described for empirical investigations.

Quality Improvement Project Reports (≤3,000 words)

IJOP acknowledges the importance of quality improvement activities to optimize EMS system performance and patient outcomes and welcomes manuscripts describing quality improvement projects.

United States regulations do not require quality improvement activities to have Institutional Review Board (IRB) or Research Ethics Board (REB) approval. The distinction between manuscripts requiring or not requiring IRB/REB approval may be subtle. Manuscripts not requiring approval will generally be those which do not apply clinical treatments or diagnostic methods that have not been previsouly established in the literature. A manuscript that explores different ways to implement a clinical treatment or diagnostic method may not require approval.

The *IJOP* shall reject manuscripts that appear to have framed an activity as quality improvement to circumvent research compliance, conduct, or reporting standards.

Authors may contact the editorial office if they are uncertain whether their work should be submitted as a quality improvement or a research manuscript.

Quality improvement project reports should adhere to the Standards for Quality Improvement Reporting Excellence (SQUIRE) guidelines (http://www.squire-statement.org). With permission of the Editorial Team, authors may submit manuscripts that use other generally accepted improvement project frameworks (e.g., IHI Model for Improvement; DMAIC).

In general, quality improvement project reports should describe the process being examined; the process change(s) that were tested; the baseline process performance level; the methods used for conducting process tests and evaluating the results; the results, including the post-intervention performance levels; any confounding variables and balancing measures; and the process change iterations as applicable.

The manuscript discussions and conclusions should highlight what the external audience can learn from the reported experience, not just the activity's internal success or failure.

Authors may provide, or editors may suggest, that some information be provided as a supplemental file so that the main paper remains concise. The supplemental content may include data sets, images, video clips, and in-depth details on methodology.

Reviews / Synthesis (≤4,000 words)

IJOP invites the submission of reviews of all types, including those with and those without meta-analytic components. In addition to the guidelines for original research provided elsewhere in these guidelines, any submissions in this category should be consistent with the Prisma 2020 guidelines for reporting systematic reviews https://www.equator-network.org/reporting-guidelines/prisma/.

Toolbox (≤3000 words)

These submissions will explain a tool or technique and describe its practical use. Where applicable, the articles may include a supplemental file or link that contains the tool and a data file where the reader may try out the tool.

Along with other standard submission file elements, the primary manuscript body pages file for Toolbox papers should contain:

- Introduction - The manuscript shall include an introduction that provides an overview of the type(s) of projects that the tool or technique could be used for or the specifics of the project that it was actually used in.
- Description of the Tool / Technique – As the central focus on the paper, this section shall provide in an in-depth examination of the tool or technique and its mechanics. Describe how the tool or technique should be applied in context of a clinical, operational, or administrative setting.
- Discussion – Discuss the underlying rationale for the tool or technique and why it may be favored over other options.
- Provide a critique of related methods. Also include discussion of any limitations of the tool or technique.
- Exercise – Where applicable, describe how to use the tool or technique in conjunction with a sample data set or scenario.

Special Reports

This submission category will be used for articles of a scholarly nature that do not fit into one of the other *IJOP* submission categories. Authors are encouraged to use the guidelines described in this document that seem to be most applicable to their Special Report, but consultation with the Editorial Team before manuscript submission is strongly encouraged.