AUSTRALIAN PARAMEDIC

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In this edition:

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PARAMEDIC OBSERVER

Latest Updates

FEATURE

Hemorrhagic Shock

FEATURE

FOAMed Highlights

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www.ausparamedic.com.au

EDITOR
Amy Cotton
amy@ausparamedic.com.au

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An Editorial Board is in place for the journal. The Board includes a number of experienced paramedics who offer expertise in various areas of paramedicine. The Board's role will be to oversee articles to ensure the content and information is accurate and timely, and to provide advice on direction for the journal.

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Submit to amy@ausparamedic.com.au

DESIGN
Studio Benji

PUBLISHER
Zodiac Media
208/365 Little Collins St,
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CONTRIBUTORS
Suggestions, content ideas or complete articles from readers are welcome and will be reviewed by the Editorial Committee. Simply contact amy@ausparamedic.com.au

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About Us

Australian Paramedic is a journal being delivered to Paramedics across Australia. Our mission is to support and improve patient care through the sharing of knowledge and information from across Australia, and at the same time aid paramedics through delivering current information from recognised and emerging leaders in emergency care.

We are independent from any employer, associations or groups and our aim is simply to provide current, relevant information to the Australian Paramedic. With an Editorial Board consisting of paramedics and emergency medical professionals we will ensure that the information provided is accurate and timely in this developing professional environment.

Australian Paramedic will continue to evolve over time with feedback and review from readers. The aim of Australian Paramedic is to share knowledge and commentary from experts in the field, as well as provide background information on topics as research and programs develop both in Australia and internationally.

As Australian Paramedic develops we hope to become the leading voice for paramedics to share news, knowledge and information.

headspace National Youth Mental Health Foundation

headspace is the National Youth Mental Health Foundation, providing early intervention mental health services to 12-25 year-olds. By ensuring help is accessed in early stages of young people's lives and providing a holistic model of support, **headspace** provides a safe space where they can get their mental health and wellbeing back on track.

headspace services cover four core areas: mental health, physical health (including sexual health), work and study support and alcohol and other drug services. Services are confidential, youth friendly and free or low cost. Young people and their families can access services face-to-face at one of 98 **headspace** centres across which can be located Australia at www.headspace.org.au, or via **eheadspace** – a national online and telephone counselling service at www.eheadspace.org.au.

Over the past 10 years, **headspace** has proudly provided over 1.8 million services through centres, online and over the phone, helping over 310,000 young people across Australia. **headspace** wants to ensure young people aged 12-25 have access to youth friendly mental health services, no matter where they live.

Alongside **headspace** centre, online and telephone support, specialised services are provided in the following areas:

- **headspace** School Support – a suicide postvention program, which assists Australian school communities to prepare for, respond to and recover from a suicide.
- Digital Work and Study Service – a dedicated team assisting young people aged 15-24 in education and work options.
- **headspace** Youth Early Psychosis Program – a program focusing on early intervention, aiming to improve the lives of young people, and their families, who are affected by psychosis.

HEADSPACE DONATIONS AND FUNDRAISING

There are many ways to support **headspace** and the work carried out in providing mental health and wellbeing support, information and services to young people and their families across Australia. **headspace** has helped hundreds of thousands of young people get their lives back on track and your support will assist us with our work.

Any donation generously provided to **headspace** goes towards community engagement and awareness, which can be specifically given towards a local centre or to National Office.

Donations to **headspace** National Office, ensures the promotion of the importance of seeking help, to break down stigma associated with mental health issues and to make sure every young person across Australia, as well as their friends and family, knows there is help available.

You can find out more about donations and fundraising through the 'Get Involved' page at

www.headspace.org.au

DID YOU KNOW?

One in four young people have experienced a mental health issue in the past 12 months – a higher prevalence than all other age groups. Alarmingly, suicide is the leading cause of death of young people, accounting for one third of all deaths.

Adolescence and early adulthood is a critical time in a person's life, with 75 per cent of mental health disorders emerging before the age of 25.

SEEKING HELP

Getting support can help a young person to keep on track at school, study or work, as well as personal and family relationships. The sooner help is received, the sooner things can begin to improve.

headspace can help any young person aged 12-25 years-old, a family member or friend wanting to seek information on youth mental health.

These are just some of the reasons someone may seek help from headspace:

- If someone is feeling down, stressed or constantly worrying
- If someone doesn't feel like themselves anymore
- If someone isn't coping with school/uni/work or finding it difficult to concentrate
- If someone is feeling sick or worried about their health
- If someone has questions about, or wants to cut down on alcohol or other drug use
- If someone wants to talk about sexuality, gender identity or relationships
- If someone is having difficulties with family or friends
- If someone is concerned about sexual health or wants information about contraception
- If someone is being bullied, hurt or harassed
- If someone is worried about work or study or having money trouble

Editor's Note

AMY COTTON

Amy can be contacted at:
amy@ausparamedic.com.au
Follow us on:
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Australian Paramedic is proud to be independent of any professional association or academic institution.

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Paramedicine Research: Seizing the Moment in Australia's Health and Medical Research Strategy

Anyone working in or around paramedicine knows the paramedic profession is changing fast. No longer just the "lights and sirens" responders, increasingly, paramedics are treating patients in their homes, managing chronic conditions, partnering with mental health services, and trialling models that keep people out of overcrowded emergency departments.

What's exciting is that these changes aren't just practical tweaks—they're research opportunities. And with Australia shaping a National Health and Medical Research Strategy, now is the time for paramedicine to claim a bigger seat at the table.

Why Research Matters

The new strategy talks a lot about coordination, workforce development, translation into practice, and using research to make the health system more sustainable. That sounds like a checklist for paramedicine research.

We've already seen how studies into extended care paramedics, non-conveyance models, and community paramedicine can improve patient care while easing pressure on emergency departments. There's also growing evidence around mental health response teams and telehealth support for decision-making in the field.

But these examples are just the start. If we want paramedics to be seen not just as responders but as innovators, we need more evidence, more data, and more visibility.

The Fit with National Priorities

Australia's health research strategy is aiming big and targeting research that genuinely improves patient outcomes. Paramedicine fits this mould perfectly.

• Reducing ED crowding and ramping: Our work in treat-on-scene and referral models speaks directly to system sustainability.

• Harnessing data: We sit on a goldmine of information—every job, every decision, every patient pathway. Turning that into usable evidence could transform policy.

• Workforce research: What training, supervision, and support do paramedics need as the role expands? How do we protect wellbeing while asking more of the workforce?

• Collaboration: Paramedicine research naturally spans EDs, GPs, community care, and mental health services. That kind of integration is exactly what the strategy is calling for.

Looking Ahead

Paramedics are already proving they can ease the pressure on emergency departments and keep ambulances turning over. But anecdotes and pilot programs only get us so far. To make a lasting impact, we need robust, visible research that feeds into national health priorities.

Australia's health and medical research strategy offers us a rare chance. If paramedicine is recognised and resourced as part of that vision, the payoff will be huge: safer patient care, smoother system flow, and a profession that continues to grow in respect and capability.

It's time to make sure paramedics aren't just responding on the front line—we're also helping lead the evidence base that shapes the future of Australian healthcare.

Australian Paramedic aims to share some of the research currently being conducted within our field. We encourage you to send in your items so that we can all learn from each other!

In this edition we have an item on overcrowding in the ED, which is an ongoing issue that needs resolution. Looking internationally this article aims to summarise some opportunities for improvement.

Ultrasound is covered in another of our original items, providing an excellent summary of this as a management tool. This is amongst our other articles that aim to highlight the latest items for your review.

Happy reading...!

ULTRASOUND

"It is not hocus-pocus, POCUS will show what is out of sight..."

Robert Rajtar and Prof. MD Mirosław Czuczwar

Preliminary diagnosis during Emergency Medical Team operations is often an "art" because of the many limitations mobile teams face. In ambulances, we do not perform specialized examinations beyond patient monitoring or imaging studies. Therapeutic decisions are based on subjective assessment supplemented by a physical exam, often supported by an ECG. Patient history is usually uncertain, and physical exam findings are often ambiguous. These situations can be clarified with point-of-care ultrasound (POCUS), which in Poland can be performed by Emergency Medical Services teams.

For many years, ultrasound was used only by specialists. Over the last decade or so, standardized POCUS protocols have been adopted. This has opened up wide possibilities for frontline medical staff, who are not imaging specialists, to expand diagnostic capabilities at the scene of an emergency. Still, it is indisputable that anyone performing such an exam must have proper training and practice. The essence of POCUS is not to provide a detailed description but rather to identify whether pathological changes are present.

The Multispecialty Regional Hospital in Gorzów Wielkopolski, Poland is about 100 km from Berlin. The Department of Anesthesiology and Intensive Care, headed by Prof. Dr. Hab. n. med. Mirosław Czuczwar, supports paramedics on duty both in the Emergency Department and in EMS teams. Prof. Czuczwar is also an excellent educator and, as I put it in the title, reveals the "hocus-POCUS" of emergency ultrasonography.

POCUS protocols help answer practical questions: "Does the organ look normal?" or "Is there fluid where it should not be?" Such findings allow us to identify the possible cause of deterioration. Conversely, a normal image indicates that the cause must lie elsewhere.

During cardiac arrest, POCUS helps guide treatment by identifying reversible causes such as hypovolemia, pulmonary embolism, pneumothorax, or cardiac tamponade. When history is limited or absent and physical exam inconclusive, ultrasound becomes invaluable.

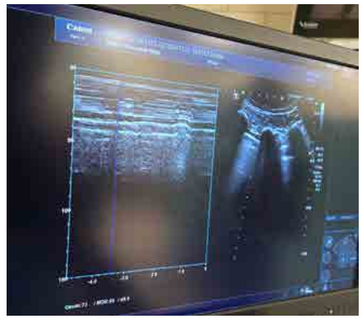
Pseudo PEA

Another diagnostic challenge is distinguishing true pulseless electrical activity (PEA) from pseudo PEA. In true PEA, ultrasound shows no mechanical cardiac activity. In pseudo PEA, however, mechanical activity is visible, although hemodynamically ineffective. Importantly, pseudo PEA carries a better prognosis, and according to statistics, may account for more than 50% of all PEA cases.

Equipment

• Any portable ultrasound machine

• Convex or sector probe: sector is best for the myocardium; convex is suitable for heart, lungs, and abdominal imaging



• Linear probe: best for vascular evaluation

Probe Placement During Cardiac Arrest

The patient will always be supine, limiting positioning. We focus on evaluating cardiac contractility and the presence of pericardial fluid. Not all projections can be obtained during CPR.

• Substernal long-axis view: Place the probe under the cricoid process, angled toward the left rib arch with the marker toward the left shoulder. Obese patients may present technical challenges.

• Parasternal long-axis (PLAX): Place the probe on the left sternal edge at the 4th–5th intercostal space, with the marker toward the right shoulder. Supine positioning may reduce clarity.

• Parasternal short-axis (PSAX): Same placement as PLAX but rotate the probe 90° clockwise, with the marker toward the left shoulder.

• Apical four-chamber view: Place the probe at the 5th–6th intercostal space in the midclavicular line, angled toward the left shoulder/armpit. Adjust as needed depending on patient anatomy.

• Substernal IVC view: Similar to subcostal heart imaging but aligned along the midline, marker toward the head. Rotating 90° counterclockwise shows the inferior vena cava, useful for assessing hydration.

• Aorta: Place the probe below the sternum, scanning from cross-section toward the bifurcation into iliac arteries, looking for stenosis, dilation, or rupture.

• Lungs: Place probes at the 2nd–3rd intercostal space along the midclavicular line, assessing pleural sliding. Absence suggests pneumothorax; fluid suggests pleural effusion. Experienced operators may also identify atelectasis, inflammation, or B-lines (signs of interstitial fluid).

• Abdomen (FAST protocol): Check for free fluid at Morrison's pouch (hepatorenal recess), splenorenal recess, and suprapubic area.

Protocols

Several POCUS protocols are used during CPR, differing in scope and focus:

• FEEL (Focused Echocardiographic Evaluation in Life Support)

• C.A.U.S.E. (Cardiac Arrest Ultrasound Exam)

• SESAME (Sequential Emergency Scanning Assessing Mechanism or Origin of Shock of Indistinct Cause)

• PEA (Parasternal–Epigastric–Abdomen)

Implementation During Resuscitation

Ultrasound complements physical examination during resuscitation, but the priority remains high-quality chest compressions and defibrillation if indicated. ERC 2021 guidelines state that rhythm assessment intervals should not exceed 10 seconds, and ultrasound should be performed within this window. This requires efficient logistics: equipment prepared in advance, images recorded for later review, and ideally, the use of a mechanical CPR device (e.g., LUCAS), which frees up rescuers.

During each 10-second pause, only one anatomical site can typically be evaluated; others must wait until the next cycle. Experienced operators may assess lungs or abdomen even during compressions.

Training

As our instructor emphasizes, theoretical training takes only a few hours; the real challenge is practice. The more often ultrasound is used, the more useful it becomes in life-threatening situations, helping identify reversible causes of cardiac arrest. Of course, ultrasound should never replace the broader clinical examination.

AUTHORS

· *Prof. MD Mirosław Czuczwar – specialist in anesthesiology and intensive care, clinician, respected academic educator, and Editor-in-Chief of anestezjologia-online.pl.*

· *Robert Rajtar, MSc, Paramedic – 22 years of experience in emergency departments and EMS in Poland and Germany, academic lecturer for three years, and active mountain ultramarathoner.*

ED OVERCROWDING IN AUSTRALIA AND INTERNATIONALLY

By Luke Roberts

OVERVIEW:
Emergency department (ED) overcrowding is a global healthcare crisis that impacts patient care, hospital efficiency, and overall health outcomes. This paper examines the causes, consequences, and solutions to ED overcrowding, focusing on Australian and international comparisons.

KEY CAUSES:
• Input Factors: Increasing patient demand, triage delays, and a lack of primary care alternatives.
• Throughput Factors: Staff shortages, long diagnostic times, and delays in clinical decision-making.
• Output Factors: Limited hospital bed availability, inefficient discharge processes, and delayed patient transfers.

IMPACT:
Overcrowding contributes to increased patient morbidity and mortality, extended wait times, staff burnout, and ambulance ramping. It also reduces the efficiency of emergency care services and leads to a higher financial burden on healthcare systems.

INTERNATIONAL COMPARISONS:
Studies from Turkey, Ethiopia, and Saudi Arabia show that overcrowding is a widespread issue, exacerbated by inadequate primary care services, hospital resource constraints, and poor patient triage systems.

PROPOSED SOLUTIONS:
• Pre-Hospital Interventions: Expanding urgent care clinics, integrating paramedics into primary care, and developing community paramedicine programs.
• In-Hospital Strategies: Increasing hospital bed availability, allowing triage nurses to order diagnostic tests, and implementing redirection policies.
• Systemic Reforms: Enhancing primary care access, improving health policy coordination, and adopting virtual emergency departments to reduce unnecessary ED visits.

CONCLUSION:
ED overcrowding is a multifaceted problem requiring urgent, evidence-based interventions. A combination of better hospital resource management expanded pre-hospital care, and systemic healthcare reforms can alleviate pressure on emergency services and improve patient outcomes.

Emergency department (ED) overcrowding is a pressing issue affecting healthcare systems in Australia and internationally. This article examines the causes and consequences of ED overcrowding, evaluates its impact on patient care delivery, and explores potential management strategies and solutions. By analysing local and global trends, this paper aims to highlight the urgency of the problem and advocate for evidence-based interventions to improve emergency care efficiency and accessibility.

UNDERSTANDING EMERGENCY DEPARTMENT OVERCROWDING

Definitions of the term overcrowding vary between sources; overcrowding is when there is a clear disparity between patient demand and the physical, staffing and structural assets available. It is key to understand that 'overcrowding' in the context of emergency departments (EDs) is happening across the world and is not an exclusive issue to selected countries or continents. The trend of overcrowding within EDs globally has been significantly increasing over the last 40 years with events such as the COVID-19 pandemic only serving as a clear reminder of how far the ED teams and resources are stretched. The three categories

that cause overcrowding are input, throughput, and output. These parameters are separate from one another, however, are interconnected, which demonstrates the complex nature of overcrowding (1).

KEY FACTORS CONTRIBUTING TO OVERCROWDING

INPUT FACTORS

Input factors as defined by our Australian Triage Score (ATS) comprise elements such as waiting time for patients in the ED, the number of patients who have arrived at the ED, as well as their severity and complexity (1). In light of the factors that an ED can control and mitigate, input is not a factor that an ED can control regarding elements such as the number of patients who arrive at an ED to be triaged or assessed (1).

THROUGHPUT FACTORS

Throughput factors are centred around internal factors of the ED system such as the processing time of our patients, more specifically from patient triage through to diagnosis and decision to discharge, admit or transfer out.

Throughput also factors assessments, examinations and investigations such as formal laboratory testing and imaging which is influenced by ED personnel surrounding their shiftwork, burnout, and quality of their work (1).

OUTPUT FACTORS

The final category to discuss surrounds output, which focuses on internal and external factors that influence patients to leave the ED. More specifically, focusing on matters within the ED clinical sphere such as the availability of hospital beds to transfer admitted ED patients to, and the delay of internal and external transport of patients from the ED to elsewhere within the same hospital or another hospital (1). Within the Australian and New Zealand context, the overall trend for our EDs and patients is that health policy and resource allocation are not matching the current demand that we are facing. In numbers, please refer to table 1 below.

Table 1. Australian and New Zealand trends over time in public hospitals

Year	Public Hospital Beds (per 1000 population)	Change in Bed Numbers	ED Admissions Increase	Reference
2011/12	2.65	-	-	ACEM 2021
2018/19	2.53	↓ 0.12 beds per 1000	↑ 25%	ACEM 2021

IMPACT OF OVERCROWDING

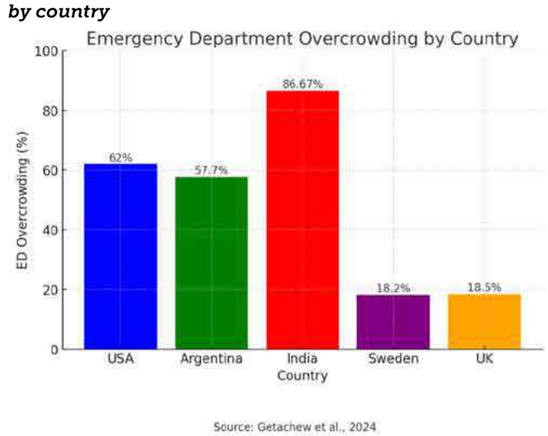
To critically analyse the Australasian impact of overcrowding in our EDs, multiple perspectives are considered, such as conducting research based on the actual and potential issues and evaluating the trend's impact on patient-centred care delivery in Australia and internationally. Within Australasia, there are two patient groups, the unwell older adults and younger adults with acute mental health issues, that typically undergo longer ED admissions. Literature in the USA reports that some solutions to mental health presentations to EDs generally are dedicated psychiatric EDs and community health professionals arranging direct mental health admissions to inpatient mental health wards instead of the same patient attending ED for triage and assessment (2).

Subsequently, these patient groups require a review of the expedited discharge planning and communication from ED and general hospital specialities to the community health teams (where available) or nominated general practitioners (GPs). Until such time, these patient groups will continue to add significantly to our prolonged length of stay and be a demand-related issue, which then reduces bed flow in the ED and the wider hospital. It is important to consider that once an ED patient requires an inpatient bed from the ED, they are transferred to this bed within a prompt timeframe. However, in clinical practice, from my experience, this is not occurring efficiently. This issue impacts a magnitude of patient care provisions in clinical practice such as triage, assessment and ambulance ramping (3).

INTERNATIONAL PERSPECTIVES ON ED OVERCROWDING

To elaborate and capture ED overcrowding as a truly international issue please refer to figure 1 below.

Figure 1. Emergency Department overcrowding statistics by country



Source: Getachew et al., 2024

This could be due to hospital level/ infrastructure, availability of registered healthcare personnel in the wider hospital and ED and inpatient bed availability for ED patients requiring inpatient admission (4). A study in Eastern Ethiopia by Getachew et al. (4) reported that ED overcrowding had strong associations with abnormal vital signs such as oxygen saturation levels and heart rate of the patients, triage times and the ED length of stay.

As seen in a study based in Turkey produced by Butun et al. (5), ED overcrowding remains persistent on an international level, with reports that outpatient services appointment systems require improvement to potentially decrease patient ED presentations. Additionally, this same study mentions that the effectiveness of primary care services and improving access and availability to this service may, in turn, reduce some of the patients presenting for non-urgent conditions to the ED (5). Also, patient education on the appropriate use of EDs and GPs is required within the community which again may have some impact on ED patient presentations leading to a slight reduction in ED overcrowding.

Now comparing these findings in Turkey to Australia. ACEM (6) reported that the minister in charge of primary care services across Australia stated that primary care services for Australians are in their worst state in over 40 years since the Medicare system was introduced in Australia. Specifically, the primary care services in Australia at present appear to be somewhat unaffordable, inaccessible and sometimes uncoordinated, which leads to the worsening of patient's chronic health over time. Worsening of patients' symptoms leads to them presenting to their respective emergency departments seeking help and support with their long-term condition(s). Improving the Medicare system and primary healthcare for every Australian needs to involve conversations with frontline clinicians such as Emergency doctors, paramedics and emergency nurses as these clinicians experience the frontline challenges in clinical practice each week (6).

CURRENT SOLUTIONS AND INNOVATIONS

Pre-hospital services can aid in alleviating some overcrowding in our EDs if we enable alternative methods to exist and work in collaboration with the wider emergency medicine speciality. One study reports an innovation trialled and developed in collaboration with the National Ambulance Service in the Republic of Ireland, whereby an Emergency Medical Technician and Specialist Emergency Registrar would be crewed on an ambulance (7). Please refer to table 2 for further information.

Table 2. Details of collaboration trial for reducing ED overcrowding in Ireland

Initiative	Location	Team Composition	Patients Attended (12 months)	Non-Conveyance Rate	Reference
Specialist Emergency Ambulance Crew	Cork, Republic of Ireland	Emergency Medical Technician + Specialist Emergency Registrar + Paramedics + Advanced Paramedics	2000+	68% (Non-Urgent 112/999 Calls)	Patton et al., 2021

This demonstrates that other pathways exist within the ambulance services and pre-hospital arena to alleviate some ED overcrowding, should we allow them to, within the great emergency medicine sphere within Australasia.

FURTHER PRE-HOSPITAL INTERVENTIONS

Integrating registered paramedics into Australia's healthcare system, particularly within Urgent Care Clinics (UCCs) and community paramedicine programs, presents a significant opportunity to alleviate Emergency Department (ED) overcrowding and enhance patient care.

The establishment of UCCs across Australia aims to divert non-critical cases from EDs. These clinics are bulk-billed, reducing financial barriers for patients. For example, the Bridgewater Medicare UCC in southern Tasmania, operational since December 2024, manages semi-urgent and non-urgent medical conditions, thereby reducing the burden on the Royal Hobart Hospital's ED.

However, the potential of UCCs is underutilized due to limited public awareness and engagement from healthcare professionals, including General Practitioners (GPs), ambulance paramedics, and telehealth services. Incorporating registered paramedics into UCCs could enhance service delivery, given their expertise in urgent and acute care. This integration has been advocated by professional bodies emphasizing the value paramedics bring to multidisciplinary teams (8).

Community paramedicine programs have been developed to manage non-urgent cases within the community, reducing unnecessary ED transports. Paramedics with advanced training provide care on-site or refer patients to appropriate services, ensuring that ED resources are

reserved for more critical cases. These programs have been particularly effective in rural and remote areas. Ambulance Victoria, in collaboration with Monash University, has been a leader in this initiative, offering a paramedic practitioner master's program.

The significant workforce of 25,238 registered paramedics in Australia represents an underutilized resource that could help address healthcare access challenges across the nation (9). Recent research suggests that community paramedicine programs could significantly reduce emergency department presentations and improve chronic disease management (10). By enabling Medicare billing rights for paramedics, similar to the existing framework for nurse practitioners, these healthcare professionals could provide essential primary care services, particularly in rural and remote areas where GP access is limited (11).

Evidence from international programs, particularly in Canada and the UK, demonstrates that paramedics working in expanded roles can effectively manage chronic conditions, provide preventive care, and reduce hospitalizations (12). Australian pilot programs have shown that community paramedics can successfully manage up to 70% of their callouts without requiring hospital transport, suggesting that expanding their scope of practice through Medicare billing rights could significantly improve healthcare accessibility while reducing system costs (13).

This community paramedicine model should be fully implemented nationwide to enable more effective utilization of the underutilized paramedic workforce across Australia. A standardized title endorsed by the Australian Health Practitioner Regulation Agency (AHPRA), along with national competency standards similar to the endorsed nurse practitioner model, would further strengthen this initiative. The Australasian College of Paramedicine (8) supports the integration of paramedics into primary and urgent care settings, highlighting their role in multidisciplinary teams.

Australia and New Zealand have expanded telephone triage services to guide patients with non-urgent conditions toward appropriate care pathways, thereby reducing unnecessary ED visits. In Australia, services like Nurse-On-Call in Victoria and Healthdirect in other states provide 24/7 access to registered nurses who offer medical advice and direct patients to suitable care options. This system could be bolstered further by employing registered paramedics in telephone triage services.

The clinical experience of frontline or private industry registered paramedics is invaluable and could serve well in a telehealth capacity. Such roles already exist and are well embedded in countries like the United Kingdom's NHS 111 service, where registered nurses and paramedics work seamlessly together in a national telephone triage capacity. Implementing similar roles in Australia may aid in retention and provide job variety for registered paramedics. The Australasian College of Paramedicine (8) supports the integration of paramedics into primary and urgent care settings, highlighting their role in multidisciplinary teams.

Ambulance services across Australia could form trial-specific teams in every state and territory to address high-call categories such as mechanical falls in the elderly population and mental health calls. For mechanical falls, a team comprising a physiotherapist, registered paramedic, occupational therapist, and geriatrician could attend incidents within suburbs with higher elderly populations, potentially reducing unnecessary ED admissions. A similar model already exists in the UK and has been performing well for many years. For mental health presentations, dispatching a vehicle with a team including a registered

Continued >

paramedic, an authorised mental health practitioner with the qualifications to section the patient if required, and a police officer could help reduce ED attendance.

In conclusion, while significant strides have been made in establishing UCCs and community paramedicine programs, there remains a clear underutilisation of registered paramedics in Australia. By integrating paramedics into UCCs, expanding their roles in telephone triage and community programs, and forming specialised response teams, Australia can more effectively alleviate ED overcrowding and enhance patient care.

IN-HOSPITAL INTERVENTIONS

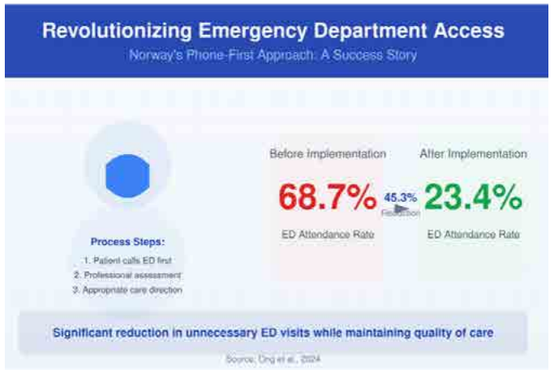
Unavailable bed space is a constant challenge and causes overcrowding in Australia's EDs due to the high volume of patients arriving and very limited bed space to assess and care for patients. This is apparent following a review of ED overcrowding that occurred in Saudi Arabia (14). Another crucial part of the research conducted by Almass, et. Al., (14) on ED overcrowding in Saudi Arabia mentions that Nurses at Triage in the ED setting not being able to undertake basic ordering of x-rays and bloods can reduce patient stay within the ED by around 20 minutes.

In some Emergency settings in Australia, they have been frequently trialling a GP to be stationed within the ED out of hours. The effectiveness of this when trialled in countries such as the UK, which has a far greater population, demonstrates minimal to no positive outcome in reducing demand and waiting times for ED patients (15). In recent literature, there is mention of redirection policies in existence in countries such as Scotland, whereby, if a patient presents to ED triage seeking assistance with a condition that has been ongoing for at least 3 days then they are reviewed by a senior doctor briefly who will then decide if they require a full ED assessment, redirection to primary care services or be given self-care advice and discharged immediately from that ED (16).

FUTURE RECOMMENDATIONS

Looking forward again to the future, one cannot discount other methods used in international EDs such as in Norwegian EDs, where patients are required to phone the ED before attending the ED in question so that an opportunity is provided for redirection by a suitably qualified healthcare professional. This method reduced ED attendance from 68.7% to 23.4% in some Norwegian EDs (16) see figure 2. In terms of adopting and trailing solutions for further reduction in overcrowding in EDs within Australia, one needs to adapt and evolve with the increasing demand for ED services.

Figure 2. Norway's phone-first approach infographic



Within the sphere of emergency care, we must move forward with adaptability, innovation and support from a magnitude of resources from Federal Governments, State / Territory Governments and on-the-ground clinicians who are emergency doctors, emergency nurses, paramedics and allied health professionals. To provide the best possible service to our patients and work towards reducing the overcrowding within Emergency Departments across Australia, we must focus on improving primary care services. The country can move forward with innovations that show promise such as Virtual EDs, whose trials in Australia involving over 2000 patients show 70% of patients who presented to the virtual ED avoided having to attend the physical ED location for further triage and assessment (17).

In addition to the above, Australia could consider dedicated low acuity response teams by state and territory ambulance services to cater for assessing patients pre-ED, and delivering contact in the community; studies show a significant reduction in the non-conveyance rate of patients from the community to a local ED. Another factor to consider for future policy and discussions for our frontline clinicians is allowing competent ED triage nurses to order bloods and x-ray testing. This on average reduces patient waiting times by 20 minutes, a substantial amount when on a larger scale (14).

CONCLUSION

A significant element of ED overcrowding that is straining EDs within Australia and internationally is the fact that hospitals do not maintain the thought of ED overcrowding as a wider hospital issue. It is imposed directly or indirectly that it is a 'systemic healthcare challenge', whereas by defining it as a wider hospital issue, they can obtain more support from the wider hospital governance team and true understanding from their executive and non-executive leaders and action plan accordingly. This line of thought could even lead to a review of internal policies and procedures such as fast-tracked discharge from an inpatient hospital bed to a community/home location for that patient.

In conclusion, emergency department overcrowding remains a critical issue that requires urgent, systemic solutions. The interplay of patient demand, resource limitations, and inefficient hospital workflows has created a crisis that compromises patient safety and burdens healthcare providers. Addressing this challenge demands a multifaceted approach, including enhancing primary care access, optimising hospital bed management, improving pre-hospital interventions, and leveraging innovative solutions such as virtual emergency departments.

International case studies highlight the potential of targeted policy interventions and community-based healthcare initiatives in alleviating ED pressures. Australia must adopt a proactive stance, integrating best practices from successful global models while tailoring solutions to its unique healthcare landscape. Effective collaboration between policymakers, healthcare providers, and emergency specialists is essential to developing sustainable strategies that improve patient outcomes, enhance system efficiency, and reduce strain on emergency services. Without decisive action, ED overcrowding will continue to pose a significant challenge to healthcare delivery, making it imperative to prioritise evidence-based reforms that ensure timely and quality care for all patients.

About the Author
Luke Roberts is a Registered Paramedic and Registered Nurse from Western Australia with a passion for pre-hospital and community based initiatives to enhance future healthcare delivery within Australia.

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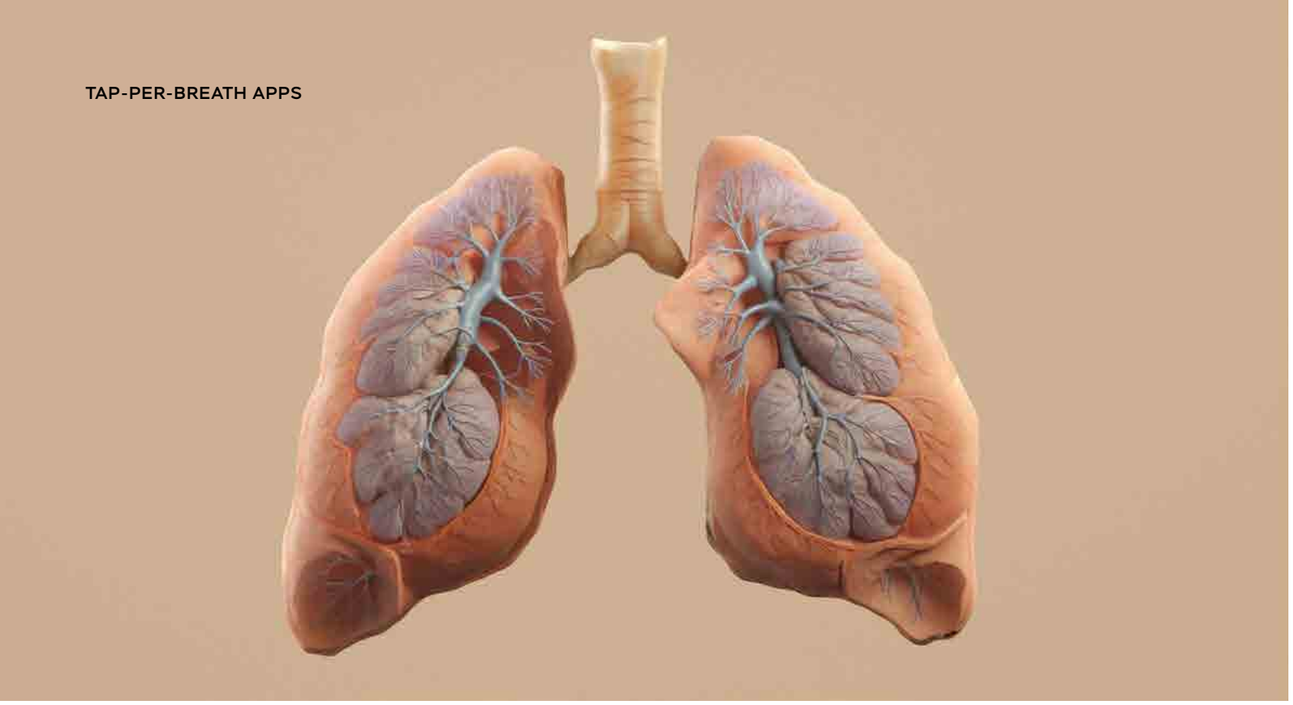
For a list of references please contact the editor



Tap-Per-Breath Apps: A Simple Tool for Measuring Respiratory Rate in Paramedic Practice

By Lachlan Sallabank[1,2]

Affiliations
[1]Victoria University, College of Sport, Health and Engineering, Melbourne, Victoria, Australia[2]Ambulance Victoria, Melbourne, Victoria, Australia

ABSTRACT

Respiratory rate (RR) is known for its ability to detect patient deterioration, though clinicians often neglect it in their standard practice. This is likely due to the awkward and time-consuming traditional methods of assessing respiration – such as counting with a watch or clock. To address this, tap-per-breath applications (tap-bpm apps) can be used to "tap-out" each patient breath, using an algorithm to estimate a rate per minute. This paper provides operational guidance for tap-bpm apps in paramedic practice, and their associated limitations. Preliminary studies suggest these apps can be accurate with substantial time-savings compared with traditional methods. Clinicians should aim to use validated tap-bpm apps such as RRate by Karlen et al. and ensure at least five regular taps for a reliable reading. Tap-bpm apps are a unique opportunity for paramedics to easily and frequently detect deterioration with respiratory rate, whilst not requiring costly consumables such as capnography. Further large-scale research in the prehospital setting is needed to determine if tap-per-breaths apps are accurate, effective, and here to stay.

INTRODUCTION

Respiratory rate (RR) ranks highly amongst the vital signs for its ability to detect patient deterioration.[1] Subtle changes in breathing often occur before any noticeable difference in heart rate, blood pressure, or oxygen saturation. Despite this, paramedics and other healthcare professionals often neglect the regular measurement of

RR, instead crudely estimating or omitting it entirely.[2, 3] Traditional methods for obtaining RR are time consuming and awkward, with clinicians commonly using inaccurate shortcuts such as counting for 15 seconds and multiplying by four.[4] The barriers to RR assessment have been well studied in hospital-based settings, often finding evidence for estimation and poor understanding of its importance.[2, 3, 5] This persistent non-adoption of respiratory rate across clinical practice highlights the need for innovative and modern solutions to address this gap in patient assessment.

TAP-PER-BREATH APPS

In a workforce of clinicians who don't value or consistently use respiratory rate (RR), experts have explored novel means to bridge this gap in patient care. Pioneered by Karlen et al. in 2014, tap-per-breath (tap-bpm) mobile applications have offered clinicians an easier method of respiration measurement.[6] These apps allow clinicians to "tap-along" with each patient breath, employing an algorithm to estimate the rate per minute. The algorithms underlying these apps vary widely, with some apps being extensively researched and transparent, and others with no evidence-base or algorithmic transparency. With the growing demand for rapid and reliable RR measurement, and the widespread use of clinical decision tools such as the National Early Warning Score 2 (NEWS2) – paramedics and ambulance services should consider the role of tap-bpm apps in respiratory assessment. Listed below are several options for tap-bpm apps, with details for their evidence-base, strengths, and limitations.

RRATE (SMARTPHONE APP)

The RRate app by Karlen et al. is a smartphone application first developed in 2014 for enabling easier RR assessment.[7] RRate prompts users to tap-along with each breath, capturing the time interval between taps (breaths), and calculating the average (median) breath-breath interval and a rate per minute estimate.[6] The app requires at least 5 regular taps to generate a RR, thus minimising the effect of irregular breaths or mis-timed taps.[6, 8]

The RRate app has been well researched over the past decade, primarily for in-hospital and paediatric contexts. One study from 2020 showed the RRate app as more accurate compared to the 15-second-count method.[9] Another recent study validated RRate as an accurate measure of RR in video-recorded adult patients, with an average app measurement duration of 22.8 seconds – significantly shorter than the recommended 30 or 60 second method.[10]

One limitation of the RRate app is that it requires the use of a smartphone, which may violate region-specific infection control procedures, and poorly integrates into the standard clinical workflow. However, RRate's well-validated algorithm provides a strong option for quick and accurate RR assessment in the prehospital setting.

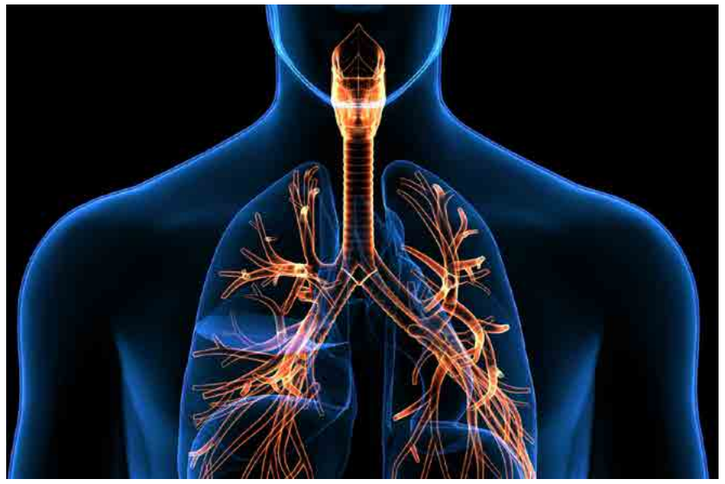
TEMPO BPM (SMARTWATCH APP)

Developed by Struan Clark, Tempo BPM is a Garmin smartwatch application originally built for musicians to measure the beats-per-minute of a song. Given its simplicity and accessibility, it has been adapted by some clinicians for measuring respiratory rate (RR) and heart rate (HR) using a tap-per-breath approach. Tempo BPM was first designed with a mean-based algorithm for calculating rate – which is easily skewed by outlier taps. However, the developer of Tempo BPM has since introduced a median-based algorithm for calculating respiratory rate (or even HR), modelling its algorithm off RRate by Karlen et al.[7]

Though not yet tested in clinical settings, Tempo BPM uses a well validated algorithm and likely offers a substantially faster and easier way for paramedics to measure respiration. To comply with infection control "bare below the elbow" policies, clinicians could loop their smartwatch to a belt or clothing loop, enabling quick access to tap out breathing, or even pulse rate. In the author's communications with Struan (the app developer), a stand-alone smartwatch respiratory rate calculator is on the horizon, which would be further tested in clinical settings for accuracy and efficacy.

MEDTIMER (SMARTPHONE AND SMARTWATCH APP)

Medtimer is an app available on smartphones and smartwatches developed by Tigerpixel Ltd, and has become popular amongst clinicians given the ease of a smartwatch-based solution. However, to the author's knowledge, Medtimer does not have any published research, validation, or algorithmic transparency for their app. The author of this review approached the app developer by email for comment on their algorithm, though has not yet received a response. Therefore, clinicians should take caution in using tools such as Medtimer without a clarity for an evidence-based algorithm, to best ensure that the respiratory values generated by the device are not erroneous or misleading.



RESPI-RATE (SMARTPHONE APP)

Respi-rate is a smartphone-based tap-per-breath app created by "medappear s.r.o.". The app instructs users to tap on each inhalation and calculates a rate/min based on the mean breath-breath time interval. Akin to the well-researched RRate app, Respi-rate requires a 95% confidence threshold to be met prior to displaying a rate. Whilst not specified directly, this app appears to mirror the RRate algorithm (though using a mean average), whilst providing a better user interface and design.

Similarly to other apps, Respi-rate has not yet been validated in peer-reviewed scientific literature – although does feature algorithmic transparency. Therefore, clinicians should still maintain caution for this app given the lack of peer-reviewed validation and the mean-based algorithm.

WHEN AND HOW TO USE TAP-BPM APPS

Given the limited available evidence for tap-per-breath (tap-bpm) apps in RR assessment, particularly in the prehospital setting – it is important to understand when, and how to best use tap-bpm apps.

When to use tap-per-breath apps

Until further research emerges, clinicians may consider the use of Tempo BPM in situations where:

1) They would otherwise estimate or guess the RR

2) Time does not allow for a measurement of more than 30 seconds (e.g. primary survey)

3) Capnography measurement is unavailable or not feasible (e.g. severe agitation prior to sedation)

When not to use tap-per-breath apps

Whilst there are no strict guidelines on the contraindications of tap-bpm apps, the author suggests avoiding the following situations:

1) Agonal breathing (waiting for 5 taps may result in poor recognition of cardiac arrest)

2) Extremely irregular respirations (e.g. Cheyne–Stokes pattern)

3) Situations requiring continuous monitoring (e.g. post-sedation care)

How to best use tap-per-breath apps

To ensure consistent and reliable readings of RR, clinicians should ensure the following:

1) RR measurement occurs in absence of patient talking (ensures regular breathing)

2) Watch the abdomen (movement occurs before chest wall expansion)

3) Tap consistently on every inhalation

4) Ensure a minimum of 5 taps (more if breathing is fast or irregular)

5) Integrate with diagnostic scoring systems such as NEWS2 for ease of triage

ALTERNATIVE USE CASES

Whilst tap-bpm apps have been well researched for their role in respiratory rate (RR) measurement for in-hospital settings, there are numerous other potential uses for this new technology. Whilst the various other use-cases for tap-per-breath apps are not well researched – clinicians and policymakers should consider their potential role in an evolving healthcare landscape.

Mass casualty triage

The prevalence of mass casualty disasters across the globe over recent decades has driven the development of tools and systems for triaging patients to an appropriate level of care. Several of these triage systems use vital sign values to direct a category of severity – including respiratory rate.[11] Clinicians faced with multi-patient emergencies are placed under substantial cognitive demand, limiting the ability for complex or cumbersome tasks – such as counting breaths with a watch or clock. This is where tap-bpm apps or devices can be used by responders to quickly ascertain a pulse or respiratory rate, allowing rapid, accurate, and specific identification of patients at risk of deterioration. However, tap-bpm devices are yet to be researched in this setting and require further development with systems and organisations to be best implemented.

Newborn heartrate auscultation

Whilst separate from the realm of respiratory assessment, obstetrics and paediatrics have long used heart rate (HR) as a guide for resuscitation algorithms in newborn babies. The current recommendation for clinicians is to auscultate newborn HR with a stethoscope over 6 seconds, which is then multiplied by 10 to estimate a rate per-minute.[12] Though this method has been criticised for its limitations in accuracy, with heart rate being underestimated compared with electrocardiogram (ECG).[13] "Tap-along" technology has been recently explored in the area of newborn HR auscultation, results showing the NeoTapAdvancedSupport app as an accurate measure for auscultated measurements in a simulation study.[14] Both paramedics and policymakers should consider this cutting edge solution for further development and research to ensure newborn patients receive timely and appropriate care.

Primary survey pulse check

Paramedics all know the importance of a pulse check during the primary survey. Though when the heart rate (HR) is extremely fast or slow, estimation can be challenging – especially when monitoring equipment isn't readily available. During a pulse check (not in cardiac arrest), using a smartwatch app to "tap-along" with each beat could allow clinicians to rapidly identify clinically relevant tachycardias or bradycardias. Subsequently streamlining the recognition of deterioration and escalation of care for unwell patients.

However as with many of the alternative use cases for tap-bpm apps, there is a lacking body of evidence for their use in these settings. Further evaluation is required to fully endorse this implementation at a systems level.

CONCLUSION

To conclude, Tap-per-breath tools offer a pragmatic solution to revitalising the clinical value of respiratory rate by reducing the ergonomic burden of manual counting and enabling accurate and efficient measurements. Current evidence is limited and therefore clinicians should carefully consider its use in clinical settings. Future work should prioritise thorough prehospital research which aims to validate tap-bpm apps in a variety of clinical scenarios. Given infection-control and workflow constraints around smartphones, purpose-built hardware (e.g., a single-button "tap" device) warrants evaluation for usability, sterilizability, and integration into clinical pathways. If these methodological and implementation gaps are addressed, tap-per-breath approaches could meaningfully improve respiratory-rate adoption, trend detection, and escalation decisions across emergency and acute care.

For a list of references please contact the editor: ***amy@ausparamedic.com.au***

Adjuvant therapies for management of hemorrhagic shock: a narrative review

Yann Daniel1,2, Frédérique Dufour-Gaume1, Amandine Vergnaud2, Manon Denis3, Louise Giaume4, Bertrand Rozec3, Nicolas Prat1,4 and Benjamin Lauzier2*

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ABSTRACT

Background Severe bleeding remains a leading cause of death in patients with major trauma, despite improvements in care during the acute phase, especially the application of damage control concepts. Death from hemorrhage occurs rapidly after the initial trauma, in most cases before the patient has had a chance to reach a hospital. Thus, the development of adjuvant drugs that would increase the survival of injured patients is necessary. Among the many avenues of research in this area, one is to improve cell survival during tissue hypoxia. During hemorrhagic shock, oxygen delivery to cells decreases and, despite increased oxygen extraction, anaerobic metabolism occurs, leading to acidosis, coagulopathy, apoptosis, and organ dysfunction.

Methods We selected six treatments that may help cells cope with this situation and could be used as adjuvant therapies during the initial resuscitation of severe trauma patients, including out-of-hospital settings: niacin, thiazolidinediones, prolyl hydroxylase domain inhibitors, O-GlcNAcylation stimulation, histone deacetylase inhibitors, and adenosine–lidocaine–magnesium solution. For each treatment, the biological mechanism involved and a systematic review of its interest in hemorrhagic shock (preclinical data and human clinical trials) are presented.

Conclusion Promising molecules, some of which are already used in humans for other indications, give us hope for human clinical trials in the field of hemorrhagic shock in the near future.

BACKGROUND

Severe traumatic injuries are responsible for 4.4 million deaths worldwide each year, which represents 8% of all deaths [1]. Hemorrhage accounts for 35–40% of these deaths, making it the second leading cause of death from trauma after direct injury to the central nervous system [2]. Death from hemorrhage is a rapid process that occurs quickly after the initial trauma, before the patient has had a chance to reach a hospital. Therefore, management must be rapid, with interventions that do not delay surgery. These procedures focus on stopping external bleeding and include extensive use of hemostatic dressings and tourniquets, with constant concern for their re-evaluation [3]; early aggressive hypothermia control; use of the antifibrinolytic agent tranexamic acid; early management of hypocalcemia; and protocolized use of blood transfusions. This is known as the damage control strategy [4]. However, the issue of time remains a primary consideration. The time to reach a hospital remains an independent factor in mortality, even in high- income countries [5].

Without questioning the principles of damage control, the development of effective, easy-to-use, adjuvant treatments to improve the survival of casualties appears to be necessary. Many researchers are currently conducting studies of transfusion therapies to enhance existing blood products or develop alternatives [6, 7]. Counteracting coagulopathy or the inflammatory processes associated with severe trauma are other promising strategies [8, 9]. Another avenue of research is to improve cell survival during tissue hypoxia, which occurs in hemorrhagic shock (HS). During HS, the oxygen supply to cells decreases and, despite increased oxygen extraction, anaerobic metabolism sets in, leading to acidosis, coagulopathy, apoptosis, and organ dysfunction [10]. In this review, we focus on molecules that could help cells cope with this situation and be used in adjuvant treatments for the initial resuscitation of severe trauma patients.

Methodology

We performed a review of the literature using the PubMed scientific database using the MeSH terms "Shock, Hemorrhagic/drug therapy." The search yielded 864 articles published since the year 2000. We refined the search by excluding articles dealing with medical devices, and then further narrowed it down by excluding articles on transfusion therapy, steroid treatment, or that specifically targeted coagulation improvement or inflammation. The studies specifically focusing on management of traumatic brain injury were also excluded, although those addressing it in the context of HS were considered. We selected molecules specifically studied in the context of HS that promote cell survival during tissue hypoxia and can be used in the pre- hospital setting. We then met to select six molecules that we deemed suitable for future human clinical trials in HS given the preclinical results already obtained in animals, particularly those that have a demonstrated effect on survival. We chose niacin, thiazolidinediones, prolyl hydroxylase domain inhibitors (PHDis), O-GlcNAcylation, valproic acid (VPA), and adenosine– lidocaine–magnesium (ALM) solution. We then searched the scientific database PubMed and ClinicalTrials.gov for these six molecules and, to be exhaustive, cross-referenced the references of the initially selected articles. We have included data from preclinical work on animal models through human research.

Results

Enhancing mitochondrial function

As the organelle responsible for producing cellular energy, mitochondria are the first to be affected by hypoxia. This results in a rapid decline in adenosine triphosphate (ATP) levels, an increase in reactive oxygen species, and the leakage of mitochondrial proteins into the cytoplasm, which ultimately leads to apoptosis [11]. In severely ill patients in septic shock, muscle biopsies have shown an association between mitochondrial dysfunction, as assessed by levels of reduced glutathione, and mortality [12]. Conversely, activation of mitochondrial biogenesis in such patients is associated with improved survival [13]. Although not as well studied in severe bleeding as it is in septic shock, mitochondrial dysfunction appears to play an important role in the pathophysiology of HS [14]. Therefore, improving mitochondrial function in the acute phase is an area of research for the management of severe trauma [10].

Niacin (Table 1)

Biological rationale Niacin is the precursor of pyrimidine nucleotides nicotinamide adenine dinucleotide (NAD), including NAD + and the reduced form NADH, and nicotinamide adenine dinucleotide phosphate (NADP), including NADP + and the reduced form NADPH. More than 500 redox reactions depend on these molecules, including mitochondrial oxidative phosphorylation and glycolysis. The NAD concentration is known to decrease in cells during HS [20]. Therefore, the hypothesis that intake of niacin or its derivatives could improve survival was tested.

Summary of preclinical works

Pretreatment with nicotinamide mononucleotide, an NAD precursor derived from niacin, in rats exposed to HS results in a decrease in interleukin 6 (IL-6) and venous lactates, and in the preservation of mitochondrial respiration assessed by high-resolution respirometry. All of these results are accompanied by an increase in survival, even when treatment is administered after initiation of HS [16–18]. Mitochondrial activity is restored, as evidenced by improvement in the NAD/NADH ratio and sirtuin 1 activity in cardiac cells, and the inflammatory response, notably the NF-KB pathway, is inhibited [16, 17].

Niacin also exerts its own action by binding to receptors expressed on immune cells, notably Gpr109a (also known as HCA2), thereby mediating anti-inflammatory effects [21]. The pathway of this receptor seems to contribute to the beneficial effect of niacin in HS [16].

A study on cardiac arrest reported a better rate of return of spontaneous circulation in mice treated with the amide form of niacin, nicotinamide, and improved cardiomyocyte contractility with nicotinamide in vitro [19]. Niacin has also shown interesting results in HS in combination with other molecules, such as niacin- dichloroacetate-resveratrol, with increased survival in the absence of resuscitation and at lower doses than if each drug was administered individually [15].

Continued >

Table 1 Summary of niacin testing in hemorrhagic shock models

Niacin				
Current use in humans	Treatment of Pellagra Lipid-lowering agent			
Supposed mechanism of action involved in hemorrhagic shock	Precursor of NAD and NADP, coenzymes involved in mitochondrial oxidative phosphorylation and glycolysis Gpr109a receptor agonist			
Demonstrated effects in hemorrhagic shock	Murine model	Preserves mitochondrial function	Preserves NAD level in tissues	Sims et al. 2018 [15] Subramani et al. 2019 [16] Jeong et al. 2015 [17]
			Preserves ATP level in tissues	Sims et al. 2018 [18] Subramani et al. 2019 [16]
			Limits lactate increase	Sims et al. 2018 [18] Subramani et al. 2019 [16] Jeong et al. 2015 [17]
		Anti-inflammatory effect	Downregulates the nuclear factor κ B (NF-κ B) pathway	Subramani et al. 2019 [16] Jeong et al. 2015 [17]
			Limits IL-6 increase in tissues	Subramani et al. 2019 [16] Jeong et al. 2015 [17]
			Limits serum IL-6 increase	Sims et al. 2018 [18] Jeong et al. 2015 [17]
		In association with resveratrol and dichloroacetate (NiDaR):	Limits IL-6 increase in tissues Limits serum IL-6 increase	Chu et al. 2019 [15]
	Porcine model	None		
Demonstrated beneficial effect on survival in hemorrhagic shock	Murine model	Survival improvement in pretreatment or given after shock induction		Sims et al. 2018 [18] Subramani et al. 2019 [16] Jeong et al. 2015 [17]
		Survival improvement in association with resveratrol and dichloroacetate (NiDaR) in pretreatment		Chu et al. 2019 [15]
	Porcine model	None		
Other effects of interest in severe trauma management	Improvement of the rate of return of spontaneous circulation in experiments with cardiac arrest in the mouse model			Zhu et al. 2023 [19]
Clinical trials in human severe trauma	None			

NAD, nicotinamide adenine dinucleotide; NADP, nicotinamide adenine dinucleotide phosphate; ATP, adenosine triphosphate; IL-6, interleukin 6

Use in humans

Niacin is a long-known vitamin referred to as vitamin B3 or PP (pellagra preventive). Its deficiency is the cause of pellagra, and it was used for its hypolipidemic effect before the discovery of statins. Niacin is a readily available, inexpensive dietary supplement already approved for use in humans, which could facilitate clinical trials. Niacin has few side effects in routine clinical practice, the most commonly reported being itching, especially of the face [22]. Toxicity studies are still required before clinical trials can be conducted. The doses utilized in the aforementioned studies (approximately 10 mg/kg intravenously and 300–1000 mg/kg orally) differ from those used in humans. For the treatment of pellagra, the recommended intravenous dose is 500 mg over 24 h. For oral daily intake, progressively increasing from 250 mg is recommended.

Table 2 Summary of thiazolidinedione testing in hemorrhagic shock models

Thiazolidinediones			
Current use in humans	Management and treatment of type 2 diabetes mellitus		
Supposed mechanism of action involved in HS	Proliferator-activated receptor gamma agonist		
Demonstrated effects in HS	Murine model	Anti-inflammatory effect: limitation in serum TNF-α, IL-6, and MCP-1 increase	Yang et al. 2011 [23]
		Protection effect against ischemia–reperfusion injuries	Chima et al. 2010 [24] Zingarelli et al. 2010 [25] Abdelrahman et al. 2004 [26] Collin et al. 2004 [27]
	Porcine model	None	
Demonstrated beneficial effect on survival in HS	Murine model	Survival improvement in animals treated after shock induction	Yang et al. 2011 [23]
	Porcine model	None	
Other effects of interest in severe trauma management	Stimulation of mitochondria biogenesis		Wilson-Fritch et al. 2003 [28] Fujisawa et al. 2009 [29] Bogacka et al. 2005 [30] Zhang et al. 2021 [31]
	Stimulation of mitochondria function in vitro		Wu et al. 2009 [32]
Clinical trials in human severe trauma	None		

HS, hemorrhagic shock; TNF-α, tumor necrosis factor alpha; IL-6, interleukin 6; MCP-1, monocyte chemotactic protein 1

Thiazolidinediones (or glitazones) (Table 2)

Biological rationale

The most documented mechanism of action of thiazolidinediones is to bind peroxisome proliferator-activated receptor gamma (PPAR-y), a transcription factor belonging to the nuclear receptor superfamily. The PPAR-y pathway is involved in inflammatory processes [33] and plays a role in mitochondrial biogenesis, especially through PPAR-y co-activator 1 alpha (PGC1a), which is deemed a master regulator of mitochondrial biogenesis [34, 35]. Thiazolidinediones have an effect on mitochondrial biogenesis [31, 36]. In humans, this is one avenue of research into neurodegenerative diseases [34]. As improved mitochondrial function could favor cell survival during HS, these compounds have been tested in this context.

Summary of preclinical works

Thiazolidinediones appear to have protective effects against ischemia– reperfusion injury during HS. Ciglitazone reduces apoptosis markers in the liver and lungs during HS in rats [24, 25]. The same results were obtained with 15d- PGJ2, another PPAR-y receptor ligand [26]. Finally, in a mouse model of HS, rosiglitazone reduced inflammatory markers TNF-alpha, IL-6, and monocytic chemotactic protein (MCP)-1; decreased organ damage; and, most importantly, improved survival in treated animals [23].

The mechanisms underlying the effects of thiazolidinediones are only partially understood [37]. Certainly, the anti-inflammatory action of thiazolidinediones may play a role in their beneficial effects during HS [38, 39], but the potential preservative effect of these compounds on mitochondrial function may also be involved. Thiazolidinediones stimulate biogenesis, but it may not be the primary effect, as it takes hours to be observed [34, 35]. Rosiglitazone normalized mitochondrial membrane potential and prevented apoptotic signaling after ischemia–reperfusion injury in an in vitro study [32]. In addition to HS, PPAR-y appears to play an important role in the development of ischemia–reperfusion injury in several models, including HS [27, 40], and thiazolidinediones have shown protective effects in this context in kidney, liver, brain, and heart tissues [27, 40, 41]. Beneficial effects of these compounds in major bleeding may also be partially mediated by this mechanism.

In summary, animal models show that Thiazolidinediones may stimulate mitochondrial biogenesis, reduce inflammation, and attenuate ischemia–reperfusion lesions in organs.

Use in humans

Thiazolidinediones, chief among which are rosiglitazone and pioglitazone, are products that have already been approved and used for many years, with great tolerance, [42] to treat type 2 diabetes mellitus because they increase insulin sensitivity. This should facilitate clinical trials in HS. However, there are none at present.

Continued >

Enhancing the cellular stress response

Prolyl hydroxylase domain inhibitors (Table 3)

Table 3 Summary of prolyl hydroxylase domain inhibitors testing in hemorrhagic shock models

Prolyl hydroxylase domain inhibitors			
Current use in humans	Stimulating effect on erythropoietin secretion used in chronic renal failure Nonformulary use: treatment of iatrogenic lactic acidosis (especially metformin-induced)		
Supposed mechanism of action involved in hemorrhagic shock	Increase of HIF-α level in the cell Activation of neoglucogenesis from lactate (Cori cycle)		
Demonstrated effects in hemorrhagic shock	Murine model	Limitation in lactate increase Improvement in hemodynamic parameters Decreased prothrombin time	Wu et al. 2024 [43]
	Porcine model	None	
Demonstrated beneficial effect on survival in hemorrhagic shock	Murine model	Survival improvement in animals treated after shock induction With maintained effects during whole blood resuscitation	Wu et al. 2024 [43]
	Porcine model	None	
Other effects of interest in severe trauma management	Stimulation of axon regeneration after spinal cord experimental trauma		Li et al. 2019 [44]
Clinical trials in human severe trauma	None		

Biological rationale

PHDis increase levels of hypoxia- inducible factors (HIFs), transcription factors expressed in response to cellular hypoxia. When exposed to hypoxic stress, the cell stabilizes its HIF levels by reducing their degradation, resulting in modulation of the cellular response to hypoxia and facilitating adaptive processes to a lack of oxygen [45]. HIFs are made up of two subunits. The a subunit is continuously synthesized and degraded by prolyl hydroxylase using oxygen as a cofactor. Therefore, it does not accumulate under normoxic conditions [46, 47]. Thus, a PHDi increases the HIF-a levels in the cell by inhibiting prolyl hydroxylase. PHDis have also been shown to act on carbohydrate metabolism by activating neoglucogenesis from lactate in the Cori cycle [48].

Thus, they could accelerate lactate clearance. The action of PHDis towards HIF-a and lactate levels has led to the hypothesis that these molecules could have a beneficial effect on cellular hypoxia, particularly in the context of HS.

Summary of preclinical works

Wu et al. recently conducted an animal experiment using MK-8617, a nonselective PHDis that they administered to rats after the onset of HS [43]. The treated animals exhibited reduced lactic acidosis, improved hemodynamic parameters, and reduced prothrombin time, in addition to enhanced survival. This survival benefit was maintained after the introduction of whole blood resuscitation, demonstrating the potential value of PHDis as standalone or adjuvant treatment in conventional hemostatic resuscitation. PHDis appear to have very broad clinical potential beyond HS [49]. In trauma, Li et al. [44] showed a stimulating effect on spinal cord healing after experimental trauma in which axon regeneration was enhanced.

Use in humans

PHDis were developed for the treatment of anemia in chronic renal failure and anemia resulting from chemotherapy due to their ability to stimulate the secretion of erythropoietin. Their efficacy in this indication has been established, though questions remain regarding their role in clinical practice due to the potential for long-term adverse effects [50]. In the context of HS, this molecule is not yet in clinical trials. In addition, no parenteral formulation of these compounds is currently available, which may limit their use in the treatment of severe trauma. The potential of these agents to enhance lactate clearance also renders them promising candidates for the treatment of lactic acidosis, including iatrogenic lactic acidosis [51], but there have been no ongoing clinical trials in this indication.

O-GlcNAcylation (Table 4)

Table 4 Summary of O-GlcNAcylation stimulation testing in hemorrhagic shock models

O-GlcNAcylation stimulation				
Current use in humans	None. Only clinical trial in humans (furthest along in phase 2 in tauopathies)			
Supposed mechanism of action involved in hemorrhagic shock	O-GlcNAc level increase would be a natural response of the cell to stress			
Demonstrated effects in hemorrhagic shock	Murine model	Glucosamine supplement	Increase in mean arterial blood pressure during hemorrhagic shock	Nöt et al. 2007 [52] Zou et al. 2009 [53]
			Increased organ perfusion in kidney and brain Improved cardiac output	Yang et al. 2006 [54]
			Mitigation of lactic acidosis	Nöt et al. 2010 [55] Yang et al. 2006 [54] Zou et al. 2009 [53]
			Mitigation of IL-6 and TNF-α increase	Yang et al. 2006 [54] Zou et al. 2009 [53]
			Reduction of neutrophil activity in the heart (assessed by myeloperoxidase levels) Attenuation of nuclear factor κ B signaling pathway activation	Zou et al. 2009 [53]
		PUGNAC administration	Mitigation of lactic acidosis Mitigation of Il-6 increase Decrease in nuclear factor κ B binding activity Attenuation of organ liver during hemorrhagic shock Reduction of neutrophil activity in the lung (assessed by myeloperoxidase levels)	Nöt et al. 2010 [55]
		NButGT administration	Increase O-GlcNAc levels in the heart Restoration of mean arterial blood pressure Restoration of ionic balance (sodium and potassium) Increased Na/K ATPase activity and expression	Dupas et al. 2023 [56] Vergnaud et al. 2023 [57]
	Porcine model	None		
Demonstrated beneficial effect on survival in hemorrhagic shock	Murine model	Glucosamine supplement	Survival improvement with administration after induction of shock	Nöt et al. 2007 [52]
		PUGNAC administration	Survival improvement with administration after induction of shock	Nöt et al. 2010 [55]
	Porcine model	None		
Other effects of interest in severe trauma management	Neuroprotective effects have been described in experimental models of cerebral ischemia and hemorrhage			Wang et al. 2021 [58] Jiang et al. 2017 [59] He et al. 2021 [60]

O-GlcNAc, O-GlcNAcylation; TNF-α, tumor necrosis factor alpha; IL-6, interleukin 6; Na/K ATPase, sodium–potassium adenosine triphosphatase

Biological rationale

O-GlcNAcylation (O-GlcNAc) is a post-translational modification of cytoplasmic, nuclear, and mitochondrial proteins that consists of the addition of a sugar, B-d-N-acetylglucosamine (or GlcNAc), to their serine and threonine residues. O-GlcNAcylation turnover is controlled by a single pair of enzymes: O-linked N-acetylglucosaminyltransferase (O-GlcNAc transferase or OGT) adds the GlcNAc motif to proteins, and O-linked N-acetyl B-d-glucosaminidase (O-GlcNAcase or OGA) removes it. OGT uses uridine diphosphate N-acetyl glucosamine (UDP-GlcNAc), which is synthesized by the hexosamine biosynthetic pathway, as a sugar donor. Thus, O-GlcNAc can be considered a metabolic sensor. O-GlcNAc levels can be increased by either glucosamine supplementation, which stimulates the hexosamine biosynthetic pathway, or pharmacological enzyme inhibition (e.g., inhibition of OGA) [61].

Continued >

This post-translational modification is involved win many, if not all, biological processes and in the development of many diseases [61]. O-GlcNAcylation of proteins also appears to play a major role in the cellular response to stress and cell survival [62, 63]. Increased levels of O-GlcNAcylation in cells before or immediately after exposure to stress (whether thermal, chemical, or hypoxic) have a protective effect by improving cell lowers O-GlcNAc levels in cells [70]. Several animal experiments using murine models of traumatic HS have shown that increasing these levels improves cardiac function and cerebral perfusion and reduces serum lactate levels. These results were obtained by stimulating the hexosamine pathway with a substrate (glucosamine) or by using OGA inhibitors, such as PUGNAc [70].

More recently, studies using another OGA inhibitor, NButGT, have shown improvement in hemodynamic and electrolyte balance via O-GlcNAcylation of renal Na/K ATPase in rats exposed to HS [56, 57]. That stimulation of Na/K ATPase may be beneficial in the acute phase of HS is an old hypothesis [71].

The process of protein O-GlcNAcylation also plays a role in the inflammatory response. In the context of severe bleeding, increasing levels of O-GlcNAcylation lead to a reduction in acute inflammation by attenuating the increase in pro-inflammatory cytokines, such as TNFa or IL-6, as has been shown after trauma in animals in which O-GlcNAcylation was stimulated [52, 54, 70]. Inhibition of the NF-kB pathway by increasing levels of intracellular O-GlcNAcylation appears to be one of the mechanisms involved [53]. This effect has also been demonstrated in vascular tissue [72, 73]. In a model of endoluminal arterial injury, rats treated with glucosamine after injury had reduced inflammation, improved healing, and a clear reduction in the formation of neointima at 14 days [74].

Improvement in these biological and hemodynamic markers induced by an increase in O-GlcNAc was associated with an increase in the survival of animals. This increase in survival was observed with [55] or in the absence of resuscitation [52] in mouse models of traumatic HS. Notably, in these experiments, the treatments were initiated after the onset of shock and did not require premedication to be effective, making their use as adjuvant therapy in severe trauma plausible.

Stimulation of O-GlcNAc could also be beneficial after the acute phase by reducing secondary complications. It improves cellular tolerance to the ischemia–reperfusion lesions that develop after HS and that are responsible for secondary multi-visceral failure. The neuroprotective effects of O-GlcNAcylation have also been described in animal models of cerebral ischemia and hemorrhage [58, 59]. Stimulation of O-GlcNAcylation in a mouse model of intracerebral hemorrhage reduced the size of the hematoma, reduced the inflammatory response in the brain, and reduced the functional consequences as assessed by neurological tests [60].

Use in humans

Dietary supplementation with Glucosamine has long been used in the treatment of osteoarthritis with great tolerance [75, 76], even in the long-term [77, 78]. However, its clinical effect in this indication is still controversial [79], though some trials have shown an improvement in painful symptoms, and even in radiological symptoms [80, 81]. All of these clinical trials used daily doses of glucosamine, the most common being 1500 mg/day in three doses for adults, which is lower than the amounts used experimentally to achieve a therapeutic effect in HS. Nevertheless, clinical toxicity studies conducted in humans with high doses of glucosamine (30–300 mg/kg in 6 h) have shown that glucosamine is well tolerated; it does not destabilize carbohydrate metabolism at high doses [82, 83]. This paves the way for clinical trials with higher doses of glucosamine.

Another means of acting on O-GlcNAcylation levels are OGA inhibitors. By reducing the activity of the enzyme that removes the GlcNAc moiety from proteins, OGA inhibitors increase proteins O-GlcNAcylation levels. These molecules are used experimentally both in vitro and in vivo. The molecules most commonly used in preclinical studies have not been tested in humans. Recently, however, new molecules have been developed and tested in humans. One of the most promising compounds is MK-8719, an OGA inhibitor with very high specificity developed by Selnick et al. [84].

It is currently being studied for tauopathies [85] and has entered a phase 1 trial in humans [86]. Still in favor of the therapeutic potential of O-GlcNAcylation in tauopathies, another group has developed an OGA- inhibiting molecule (LY3372689) [87] that is currently being evaluated in a phase 2 trial in humans because its safety profile was shown to be acceptable in phase 1 clinical studies [88]. These data raise hopes for clinical trials in fields other than neurodegenerative pathologies, and especially in severe trauma and HS.

Histone deacetylase inhibitors (Table 5)

Table 5 Summary of histone deacetylase inhibitors testing in hemorrhagic shock models

Histone deacetylase inhibitors					
Current use in humans	Treatment of bipolar disorder and epilepsy (e.g., valproic acid) Preventive treatment of migraine (e.g., valproic acid) Anti-neoplasic (e.g., suberoylanilide hydroxamic acid)				
Supposed mechanism of action involved in hemorrhagic shock	Promotes chromatin decondensation, facilitating transcription mechanisms				
Demonstrated effects in hemorrhagic shock	Murine model 21/03/2025 14:01:00	Valproic acid	Protecting effect against organ damage during hemorrhagic shock	In liver	Gonzales et al. 2006 [89] Gonzales et al. 2008[90]
				In lung	Kochanek et al. 2012 [91] Fukudome et al. 2012 [92]
				In kidney	Zacharias et al. 2011 [93]
				In heart	Wang et al. 2016 [94]
			Downregulation of transcription of genes involved in apoptosis and cell-death pathways		Zacharias et al. 2011 [93] Butt et al. 2009 [95]
		Suberoylanilide hydroxamic acid	Protecting effect against kidney damage during hemorrhagic shock Downregulates genes transcription involved in apoptosis and cell-death pathways		Zacharias et al. 2011 [93]
		Tubastatine A	Protection against lung injury during hemorrhagic shock Diminution of endotheliopathy of trauma		Bruhn et al. 2018 [96]
			Maintains mitochondria pyruvate dehydrogenase activity after hemorrhagic shock Downregulates genes transcription involved in apoptosis and cell-death pathways		Chang et al. 2015 [97]
	Porcine model	Valproic acid	Prevention of platelet dysfunction during hemorrhagic shock		Bambakidis et al. 2017 (ex vivo study) [98] Dekker et al. 2014 [99]
			Downregulation of transcription of genes involved in apoptosis and cell-death pathways in the brain		Dekker et al. 2014 [100]
			Mitigation of lactic acidosis and coagulopathy after hemorrhagic shock		Causey et al. 2013 [101] 21/03/2025 14:01:00
Demonstrated beneficial effect on survival in hemorrhagic shock	Murine model	Valproic acid	Administrated without resuscitation, as pretreatment before hemorrhagic shock induction		Gonzales et al. 2006 [89] Gonzales et al. 2008 [90]
			Administered after hemorrhagic shock induction		Zacharias et al. 2011 [93] Shults et al. 2008 [102] Butt et al. 2009 [95] Fukudome et al. 2010 [103]
		Tubastatin A	Administered without resuscitation after hemorrhagic shock induction		Chang et al. 2015 [97]
		Suberoylanilide hydroxamic acid	Administered without resuscitation after hemorrhagic shock induction		Zacharias et al. 2011 [93]
	Porcine model	Valproic acid	Administered after hemorrhagic shock induction, during saline resuscitation		Alam et al. 2009 [89]
			Administered after hemorrhagic shock, during dried plasma resuscitation		Alam et al. 2011 [93]
			Administered after hemorrhagic shock, along with packed red blood cells		Williams et al. 2019 [104]
		ACY-1083	Administered after hemorrhagic shock, along with saline resuscitation		Biesterveld et al. 2020 [105]
Other effects of interest in severe trauma management	Valproic acid limits size of brain lesion in traumatic brain injury associated to hemorrhagic shock models				Jin et al. 2012 [105] Imam et al. 2013 [107] Nikolian et al.2017 [108] Halaweish et al. 2015 [109]
Clinical trials in human	Severe trauma	None			
	Cardiac surgery	recruiting trial To study the protective effect against organ damage during cardiac surgery (kidney and heart)			Val-CARD trial [110]

Biological rationale

Histones are nuclear proteins that DNA wraps around to form chromatin. Acetylation of the lysine residues on histones relaxes the chromatin, making the DNA more accessible to transcription factors. Conversely, hypoacetylation condenses chromatin and makes gene expression more difficult. This hypoacetylation of histone proteins is mediated by histone deacetylase in HS. Histone deacetylase inhibitors counteract this phenomenon and facilitate transcription dynamics, enabling the activation of mechanisms that promote cell survival [111, 112]. There are 18 histone deacetylase insomnia in humans with different actions in different tissues [113, 114]. Some inhibitors are class- specific, whereas others are nonspecific and act on several classes of histone deacetylase.

Summary of preclinical works

Among the nonspecific histone deacetylase inhibitors, VPA is the most widely studied in the context of trauma. Like other nonspecific inhibitors, VPA first demonstrated its efficacy on the survival of murine models of HS as a pretreatment [115]. This effect was then confirmed when

Continued >

VPA was administered after the induction of shock to better match clinical practice. In murine models of lethal HS, administration of VPA and suberoyanilide hydroxamic acid, another nonspecific histone deacetylase inhibitor, in the absence of resuscitation increased the survival rate by > 50% compared to the control group [102]. Nonselective histone deacetylase inhibitors have also been shown to have a cell protective effect during HS [91–93].

In addition, VPA has been tested in large animal models with protocols combining severe trauma and HS. Treatment with VPA improved survival compared with resuscitation with isotonic saline [89], and this effect was maintained when combined with standard resuscitation with transfusion [104]. Nonselective histone deacetylase inhibitors have been shown to improve survival in HS in murine and porcine models, either alone or in combination with standard resuscitation [116].

Although some studies have shown no efficacy of histone deacetylase inhibitors on mortality in pig models of HS [117, 118], a meta-analysis including 101 studies exploring the effect of histone deacetylase inhibitors (specific and nonspecific) on both rodents and pigs in the context of ischemia–reperfusion, sepsis, and severe trauma clearly demonstrated an effect of histone deacetylase inhibitors on the mortality of treated animals [119]. This work also demonstrated cellular protection in the heart, brain, and kidneys, reduced inflammation, and reduced apoptosis in animals treated with histone deacetylase inhibitors. Therefore, the biological effect of histone deacetylase inhibitors in the context of severe trauma is clearly accepted, but further studies are needed before clinical trials can be planned in humans. The best specific or nonspecific inhibitors, and their most appropriate dosage, need to be defined.

Use in humans

VPA is the compound most likely to be tested in humans for HS in the near future because it is already authorized for and widely used in humans for the treatment of epilepsy and prevention of migraines [120]. Although the usual dosage for humans is between 20 and 30 mg/kg, doses of at least 250 mg/kg appear necessary to obtain a clinically relevant effect on HS in rat models [121]. Lower doses may be sufficient in humans given the hypermetabolism of rodents [122]. Moreover, a toxicity study carried out in healthy volunteers demonstrated good tolerance of 140 mg/kg [123]. Obviously, further studies are required in patients in shock, as the pharmacodynamics of the drug may be different in this type of patient. To the best of our knowledge, no trial is currently underway in the field of trauma, as the one listed at clinicaltrials.gov was stopped before completion due to enrollment difficulties [124]. However, a clinical trial is currently being conducted in the United Kingdom to evaluate the efficacy of VPA premedication in protecting the heart and kidneys during surgical procedures in cardiac surgery patients [110].

A systemic approach: adenosine–lidocaine–magnesium solution (Table 6)

Table 6 Summary of adenosine–lidocaine–magnesium solution testing in hemorrhagic shock models

Adenosine–lidocaine–magnesium solution				
Current use in humans	Cardioplegia solution in cardiac surgery			
Supposed mechanism of action involved in hemorrhagic shock	Not yet really identified			
Demonstrated effects in hemorrhagic shock	Murine model	Increase in mean arterial blood pressure and other hemodynamics parameters	With no resuscitation	Letson and Dobson 2011 [125] Letson and Dobson 2011 [126] Letson et al. 2012 [127] Letson and Dobson 2015 [128] Letson et al. 2017 [129]
			With reinfusion of shed blood	Letson and Dobson 2011 [125]
		Significant decrease in PT and aPTT (return to baseline)		Letson et al. 2012 [127] Letson and Dobson 2015 [128]
		Correction of ROTEM parameters		Letson and Dobson 2015 [128] Letson et al. 2017 [130]
		Decrease in the amount of lost blood over 6 h compared to saline controls Increase in gut and kidney perfusion during shock		Letson et al. 2017 [129]
		Mitigation of anemia Prevention of the increase of plasma level of IL-1α and IL-1β, and IL-2, IL-6, and TNFα Prevention of the decrease of plasma level of fibrinogen Maintaining normal platelet aggregation (collagen and ADP-induced)		Letson et al. 2017 [130]
		Could promote dominance of the parasympathetic system in the heart during hemorrhagic shock (assessed by the ratio of M2 muscarinic receptors to β-1 adrenergic receptors), which would be associated with increased survival		Letson et al. 2022 [131]
	Porcine model	Improving in mean arterial blood pressure, cardiac output, and other hemodynamic parameters		Granfeldt et al. 2012 [132] Granfeldt et al. 2014 [133] Granfeldt et al. 2014 [134] Letson et al. 2020 [135]
		Mitigation of lactic acidosis		Granfeldt et al. 2014 [133] Granfeldt et al. 2014 [134] Letson et al. 2020 [135] Letson et al. 2019 [136]
		Reduce fluid requirement to maintain Mmean arterial blood pressure during hypotensive resuscitation		Granfeldt et al. 2012 [132]
		Increase O2 delivery to tissues		Letson et al. 2020 [135]
		Improve cardiac and kidney functions with a maintained effect after reinfusion of shed blood		Granfeldt et al. 2012 [132] Granfeldt et al. 2014 [133]
		Mitigates fibrinogen decrease and maintains ROTEM parameters		How et al. 2019 [137]
		Modification of expressions of genes involved in mitochondria function		Letson et al. 2019 [136]
Demonstrated beneficial effect on survival in hemorrhagic shock	Murine model	Significant improved survival compared to control; Adenosine–lidocaine–magnesium solution administrated after shock induction		Letson and Dobson 2011 [125] * Letson et al. 2017 [129] Letson et al. 2019 [136] *Maintained effect after resuscitation with shed blood*
	Porcine model	Survival gains not statistically significant		Letson et al. 2020 [135]
		Negative: Survival with Hextend and Ringer lactate solution would be greater than survival with Adenosine–lidocaine–magnesium solution		How et al. 2019 [137]
Other effects of interest in severe trauma management	Limit ischemia reperfusion injury after resuscitative endovascular balloon occlusion of the aorta in porcine models			Conner et al. 2021 [138] Franko et al. 2022 [139]
	Reduces infarction area and neurological deficits after experimental cerebral ischemia in murine model			Wang et al. 2022 [140]
	Significant reduction of mortality after moderate traumatic brain injury in murine model			Letson and Dobson, 2018 [141]
Clinical trials in human severe trauma	None			

PT, prothrombin time; aPTT, activated partial thromboplastin time; ROTEM, rotational thromboelastometry; TNF-α, tumor necrosis factor alpha; IL-6, interleukin 6; IL-1α, interleukin 1α; IL-1β, interleukin 1β; IL-2, interleukin 2; ADP, adenosine diphosphate

Biological rationale

ALM solution was empirically developed for cardiac surgery as a protective solution in cardioplegia. It consists of adenosine to inhibit the sinus node, lidocaine to reduce the amplitudes of action potentials by blocking voltage-dependent sodium channels, and magnesium to stabilize the cardiomyocyte membrane. The good results observed during surgery on the heart have led to the idea of testing this solution in the context of traumatic HS by administering it systemically. The doses required when the three molecules are used together are much lower than the usual doses of each of the three drugs, suggesting a potentiation phenomenon between them. Another enigma is that the effects of ALM solution can last several hours in animal experiments, but the half- lives of the three molecules are quite short (< 1 min for adenosine and ~ 5 h for lidocaine and magnesium) [142].

Summary of preclinical works

In murine models of HS, ALM solution has resulted in a significant reduction in mortality, including when administered after the onset of shock [125, 129, 131]. The solution has also been tested in pig models of HS [133–135]. In these models, the effect on mortality was not as obvious, but multiple biological parameters were favorably modified,

Continued >

including hemodynamic parameters, lactate levels, and renal function. One group reported lower efficiency than conventional resuscitation using normal saline [137], but in their model, pigs were anesthetized with buprenorphine, which could have an impact on mortality [142].

Initially developed for cardioplegia, ALM solution has clear cardiovascular effects during HS. It seems to reduce vascular resistance while stimulating cardiac contractility, thereby increasing the compliance of the cardiovascular system [133]. Its action on the cardiovascular system could be partly mediated by the autonomic nervous system. Authors have described an association between the overrepresentation of parasympathetic system receptors in cardiac cells (i.e., the ratio between M2 and B-1 muscarinic receptors) and the survival of rats treated with ALM solution [131]. A reduction in xsanguination has also been reported in a mouse model [129].

ALM solutions also appear to play a role in the global blood failure that occurs during HS. A study in rats with HS showed a correction of viscoelastometric parameters and prothrombin time in animals treated with ALM solution [128]. These results have been confirmed in other studies, including in pig models [130, 137]. Endotheliopathy also appears to be a target of ALM solutions. In a mouse model, treatment was shown to limit the rise in syndecan-1, the main marker of endotheliopathy [141], and to help maintain glycocalyx thickness (intravital microscopy) in treated animals with HS. Finally, the cellular oxygen debt appears to be reduced by treatment. In a pig model, ALM solution reduced brain oxygen consumption, reduced the expression of hypoxia-inducible factors, and reduced venous lactate levels [135]. Finally, platelet function may be improved by ALM solution according to aggregometry studies carried out in rats with HS [130].

Although its cellular mechanisms remain unclear, ALM solution has a clear biological effect and holds promise for HS by targeting both cardiac function and blood failure in the acute phase.

Use in humans

Initially developed for this indication, ALM solution is used by cardiac surgery centers as a protective solution in cardioplegia and has shown good results [143]. ALM solution provides better myocardial protection, and the time required to resuscitate the heart post-surgery appears to be shorter when it is used [144, 145]. Each component of this solution is a drug already authorized for human use. The affordability and availability of these products, along with ALM solution use in cardiac surgery, suggest potential for clinical trials. However, none are currently underway. The incomplete understanding of its mechanisms in shock may be a contributing factor to this situation.

Discussion

Here, we presented six molecules that we consider to be particularly promising in the field of HS. This work does not claim to be exhaustive; it does not address all candidate molecules for adjuvant treatment in HS, and this is an obvious limitation. Nevertheless, we think these molecules are good candidates for future clinical trials.

The drugs presented here are promising, but most of the experiments were carried out in murine models, and less often in porcine models. Therefore, more work is needed to confirm the results in larger animals and humans. When a biological model is changed, the initial results are not always reproduced [146, 147]. A major limitation of many of the studies investigating adjuvant treatment for HS is indirect assessment of the efficacy of the molecule under investigation. Many works presented here fall into this category. Indeed, the parameters used, such as biomarkers of mitochondrial function, plasma levels of inflammatory markers, or ischemia–reperfusion lesions in organs, do not directly reflect the ability of these compounds to improve survival.

Even if certain markers appear to be highly relevant (e.g., hemodynamic parameters), they remain secondary indicators that are not systematically associated with a gain in survival. Therefore, in this work, we selected molecules that have shown improved survival in animal models, which appears to be the only valuable primary endpoint. Most of these molecules have, so far, only shown survival gains in murine models (i.e., niacin, thiazolidinediones, PHDi, O-GlcNAc, and ALM solution), whereas histone deacetylase inhibitors have also shown survival gains in swine models. HS constitutes a systemic pathology, exerting its effects on the entirety of the body. In this regard, a holistic approach must be adopted when appraising novel therapeutic interventions.

Another limitation of preclinical results is the stereotypical nature of the trauma models studied. Researchers need perfectly calibrated and reproducible clinical situations to identify and dissect the biological mechanisms discovered. Despite the increasing complexity of models and use of larger models to approximate human biology, clinical

trials do not always achieve the expected results. Clinical presentations are extremely diverse: traumas may be open or blunt, patients may be young or old, and they may have comorbidities and take medication. Treatment is not always comparable in terms of the time it takes to implement certain therapies or hospital access. Many factors, such as the ingestion of toxic substances, can also alter the body's response to trauma [148].

Similarly, in clinical settings, the tested molecules are to be administered to patients who have received other medications, including blood products, potentially in substantial doses. Blood transfusions in patients with severe trauma modify the cytokine environment regardless of the trauma itself [149]. Consequently, the outcomes observed for the molecules described in this study may differ in clinical trials, particularly for those involving inflammation-associated signaling pathways.

For this reason, in the field of HS, many molecules are often tested first in surgical patients undergoing hemorrhagic procedures, who undergo the same surgery and are, therefore, more comparable. Similarly, studies in war-wounded soldiers, who are more comparable in terms of age, comorbidities, and time to treatment, often make it easier to draw conclusions than studies in civilian populations. Thus, caution should be exercised when drawing conclusions from preclinical work in animal models.

In the area of severe trauma, there are a number of compounds that, despite a strong preclinical base, have struggled to demonstrate a benefit in clinical trials [142, 150]. Most of the molecules presented here are already approved for human use in indications other than severe bleeding. This is the case with niacin, glitazones, glucosamine, and VPA. Thus, their toxicological profiles in humans have already been partially established.

This is the concept of "drug repurposing," which is becoming increasingly prevalent, particularly from an economic standpoint [151]. However, for the compounds we have presented here, phase 1 trials will be unavoidable. The drugs will behave differently in a severely traumatized patient. Absorption may be altered, as well as renal and/or hepatic clearance. In the case of severe bleeding, distribution factors may also be different. In addition, enzyme function may be altered in hypothermia, which is

often associated with severe trauma. The other need is to determine the optimum dosage for humans suffering from trauma.

In the case of stimulating O-GlcNAcylation of proteins, inexpensive inhibitors, such as NButGT, have never been tested in humans, and those that have entered human clinical trials are still in phase 2 and for indications in chronic pathology that may have drawbacks over a long period of treatment [18]. All of this must not detract from the ethical requirements of clinical research [152], and toxicity studies will be inevitable before such molecules can be used in severe trauma patients. However, the prognosis of traumatic HS is so poor that ethics committees may consider this when deciding whether to allow a clinical trial to proceed. The risk of potential long-term side effects can be weighed against the high short-term mortality.

This reasoning is quite common in major trauma and has been applied, for example, to the risks associated with the transfusion of non-Rh(D)-negative whole blood to young women of childbearing age [153]. Moreover, the short-term prognosis of severe trauma patients is poor enough to consider compassionate use of molecules that have not yet been well studied in this indication.

Conversely, if we were to develop molecules for prophylaxis, administered prior to the onset of shock, it would be imperative that no serious side effects be tolerated given that they would be administered to healthy individuals. Beyond premedication during surgery, preventive treatment could be given to certain professionals, such as soldiers or firefighters, before going on dangerous missions, as some authors envision for tranexamic acid [154].

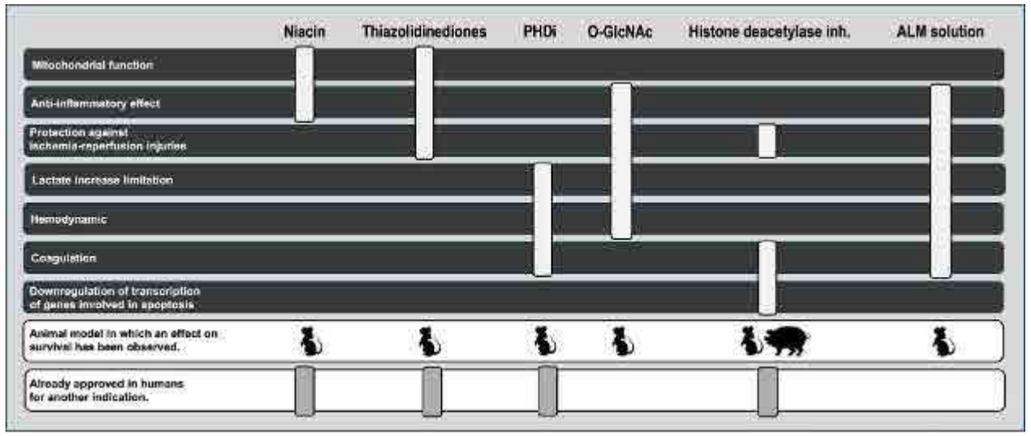

Fig. 1 Schematic representation of the potential modes of action of the different molecules according to the pre-clinical data obtained in animals. PHDi, prolyl hydroxylase domain inhibitors; O-GlcNAc, O-GlcNAcylation; Histone deacetylase inh, histone deacetylase inhibitors; ALM solution, adenosine–lidocaine–magnesium solution

Figure 1 shows the pathways by which the various molecules presented in this paper may affect survival in HS based on preclinical results obtained in animal models. Some molecules appear to act through multiple pathways. We can also ask whether these molecules may work in combination, potentiating one another. This is the approach adopted by the teams working on ALM solution [142] and Chu et al. [15], who tested a solution combining niacin, dichloroacetate, and resveratrol. In these two examples, the doses needed to achieve a biological effect are much lower when the molecules are used together than the usual doses of each drug used alone. Lower doses could also mean fewer side effects when translated into humans, and combining molecules increases the chances of achieving a biological effect in a genetically heterogeneous population [142].

Conclusion

Traumatic HS remains a major public health problem. Without questioning the concept of damage control resuscitation and earliest possible surgery, it is legitimate to seek adjuvant treatments to increase cell survival in the acute phase and improve the prognosis of these casualties. Here, we presented compounds with clear therapeutic potential that deserve to enter clinical trials soon. However, the promising results of the preclinical studies presented here should not blind us to the frequent failures of animal-to-human translation.

For a list of references please contact the editor:
amy@ausparamedic.com.au

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What can we learn from the IMG experience?

Posted 17 September 2025

The AMA's review of International Medical Graduates (IMGs) highlights a system fundamentally reliant on overseas talent to fill systemic domestic workforce gaps, particularly in rural areas. https://tinyurl.com/42rxwsuc

The report found IMG's faced four main challenges: cultural and communication barriers, system and workflow adaptation difficulties, lack of professional integration and support, and personal and social challenges. https://tinyurl.com/2efhruzv

It's also worth looking at the Dawson Review which promises sweeping reforms to enhance transparency and improve trust among both practitioners and consumers. https://tinyurl.com/2s4f32rd

The Dawson review complements earlier reforms, such as the Kruk Review (2023), which addressed barriers for overseas-trained health professionals. https://tinyurl.com/2p7x78v7 It also aligns with Ahpra's current broader agenda https://tinyurl.com/r3w63hvw and supports the Cormack Review (2024).

If those issues sound familiar to paramedics, I'm not surprised. But there is a significant difference: the primary challenge for paramedicine is not a shortage of qualified individuals or a reliance on international entrants, but a failure to fully integrate and utilise the growing cohort of local graduates across the wider health domain.

So a key lesson for paramedicine is not how to manage recruitment, but how to overcome protectionist and siloed thinking that has inhibited the practice of paramedicine and other alllied health professions. Instead we need to champion the mobility and skills of our available domestic paramedicine workforce.

What are some other lessons for paramedicine?

The cost of protectionism and silos: The IMG history is rife with barriers designed to protect the domestic medical profession. For paramedicine, the parallel issue is the internal barriers within the health sector that keep local paramedics siloed within perceived ambulance service roles.

The lesson here is that protectionism ultimately hurts the patients and the professionals themselves by limiting the available workforce resources, restricting career pathways and constraining innovative care models.

The IMG recognition process has struggled to assess whether overseas training is "equivalent." For local paramedics, the problem is that the health system often fails to recognise how paramedic skills are applicable to roles in primary care, community health, mental health, and rural generalist teams. The system has been slow to assess or accept their skills for non-traditional roles.

The medical system's reliance on IMGs to staff rural areas reveals a failure to attract domestic graduates to those locations.

Paramedicine faces the same rural distribution problem but with one difference - Australia has paramedics working in the ambulance services that cover whole jurisdictions including rural, regional and remote areas. But much more could be achieved if our clinics and hospitals also employed paramedics.

Without deliberate strategies to create attractive, sustainable career pathways in underserved areas, local graduates will seek opportunities elsewhere, including overseas. And that's happening.

Much has been said about the human and financial cost of a slow, complex regulatory system for IMGs. For local paramedics, the bureaucratic inertia manifests as rigid funding models, industrial agreements, and clinical governance frameworks that prevent paramedic skills from being deployed in new settings, leading to frustration, underemployment, and workforce attrition.

Those barriers are exacerbated by discriminatory government policies that don't recognise paramedics for a range of scholarships and support mechanisms including 'prac placement' benefits.

Learning from the IMG experience, paramedicine needs to focus on breaking down internal barriers for our local graduates. Unleashing the potential of the health workforce was a major focus of the Cormack Inquiry. https://tinyurl.com/4vavk6x5

Now that paramedics are registered practitioners, the next step is to prove their worth across the entire healthcare system. This means working with policymakers and other health leaders to create new meaningful roles for paramedics in primary care, clinics, community health, hospital-based and other facilities.

Keys to driving sustainable change are funding and regulation. Advocacy is needed for changes to Medicare Benefits Schedule (MBS) items and other funding models to allow paramedics to bill directly for services. Embedded administrative guidelines and regulations also need review to ensure they better recognise paramedics (and other AHPs) as healthcare providers.

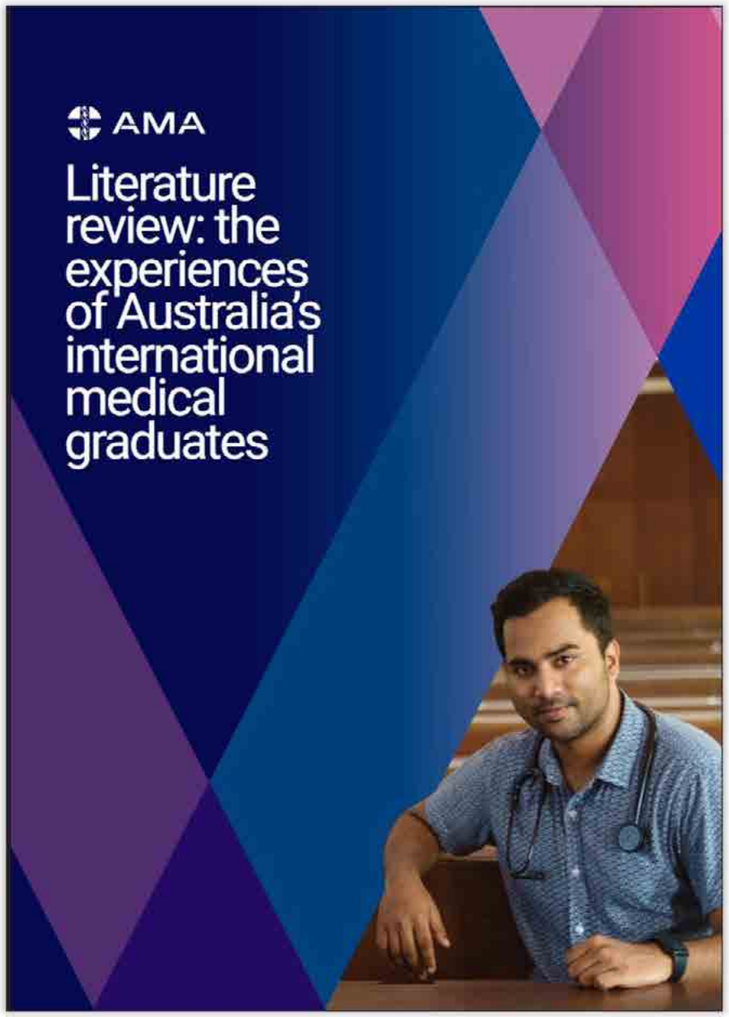
We should develop clear career pathways by creating post-graduate specialisations and credentialling (e.g., in community paramedicine, mental health, primary care) that formally qualify local graduates for these expanded roles, giving them a recognised career ladder. These specialised roles are already recognised in Aotearoa New Zealand. https://tinyurl.com/yc5uzht3

With around seven million people (or 28% of Australia's population) living in rural and remote areas that are underserved by health services, the profession has an opportunity to build domestic metro and rural professional pipelines.

That means implementing better incentive programs, scholarships, and supported placements for local paramedic graduates to build careers in rural and remote (and metro) practice.

We must also educate the community including politicians and other healthcare professionals on the value of paramedics. This will help to break down barriers and perceived stereotypical 'silos' of practice and help integrate the profession into new multidisciplinary teams.

In short, the IMG experience teaches us that the greatest risk is not a lack of qualified people, but a system that fails to utilise them effectively.



Registered Paramedics in Australia - June 2025

Posted 27 August 2025

The Paramedicine Board of Australia has published the latest statistical summary of registrant data for the quarter ending 30 June 2025. You can access the data here: https://tinyurl.com/4jxz5tta

The total number of Australian registered paramedics shows an increase of 218 over March 2025 and now stands at 26603.

The proportion of female practitioners has increased slightly to 52% of total registrants, with the highest female percentages recorded in Victoria (55.2%) and South Australia (55.2%). The lowest female percentage remains in Western Australia (46.9%). <image>

Paramedics declaring no fixed Principal Place of Practice continue to increase. This group now numbers 561 and is more female-oriented at 55.1%.

Aboriginal and Torres Strait Islander paramedics have increased slightly (+7) to 575 (2.16%), with the highest number still in NSW (227 or 3.36%). Queensland follows with 179, or 2.65% of that state's paramedics.

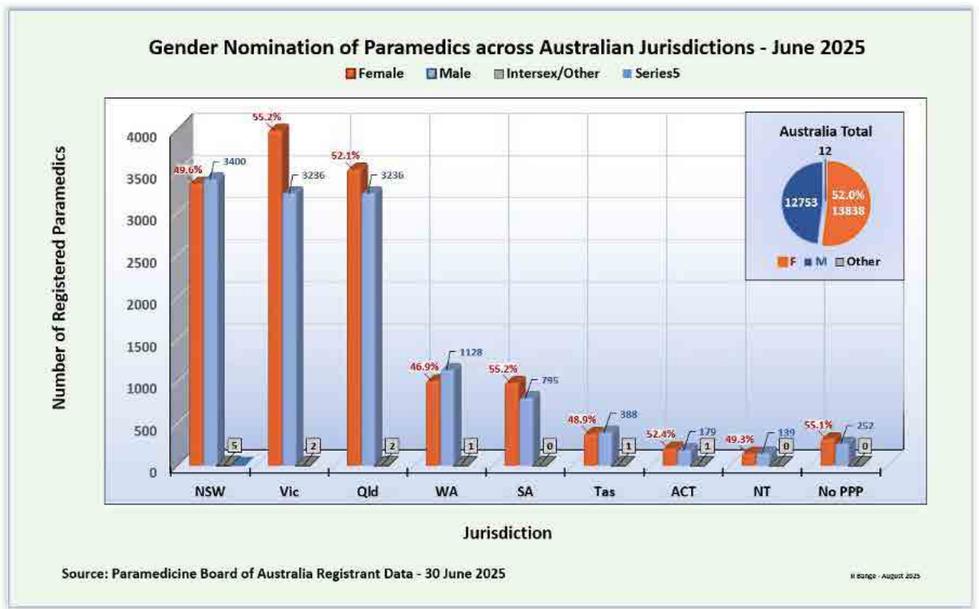
The NT remains a significant outlier with only 10 (3.65%) Indigenous paramedics. This is well below the composition of the population, which is more than 30% Indigenous. <image>

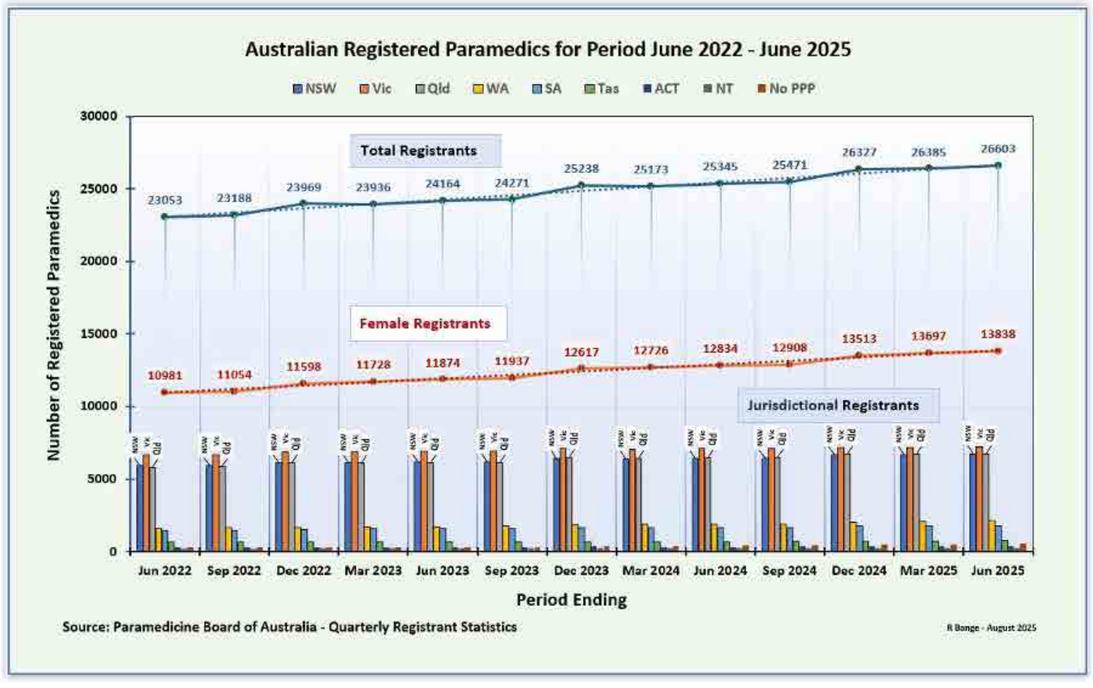
The three states of Queensland, NSW, and Victoria continue to account for more than three-quarters of Australia's total registrants, collectively making up 77.9% of the national total. <image>

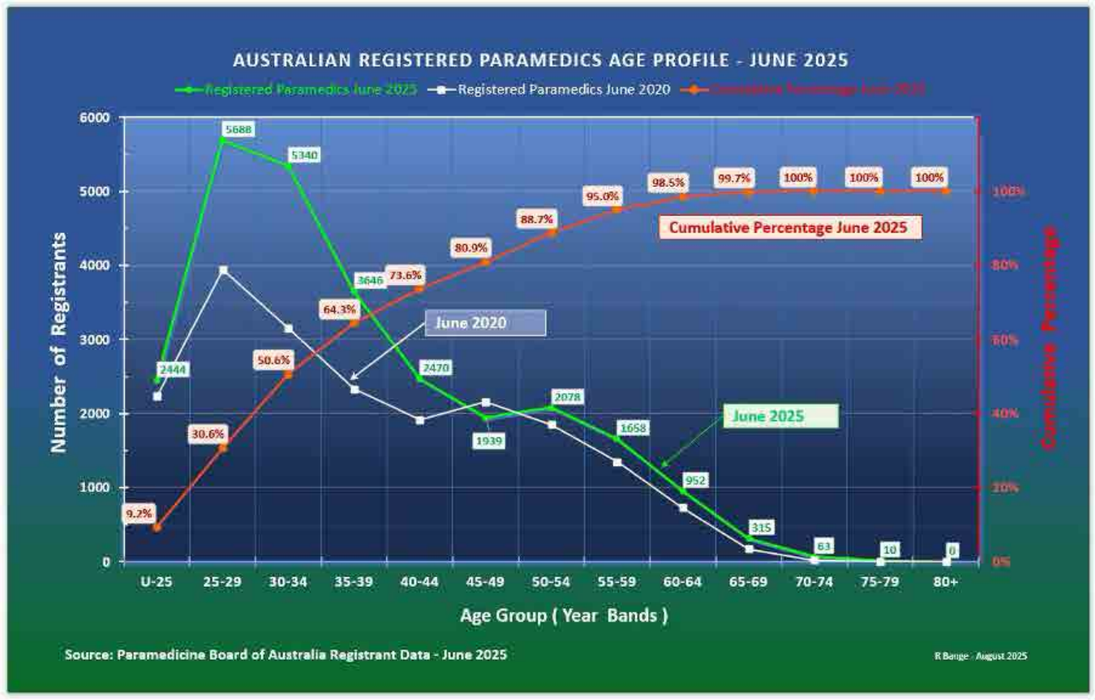
The number of non-practising registrants follows the usual cyclic pattern, with the mid-year number dropping to 843 or 3.2% of paramedics nationally. This percentage is well below the non-practising cohort in Aotearoa New Zealand (16.4%), but the slow growth trend as a proportion of total registrants remains a concern. https://tinyurl.com/3r2vvb9y

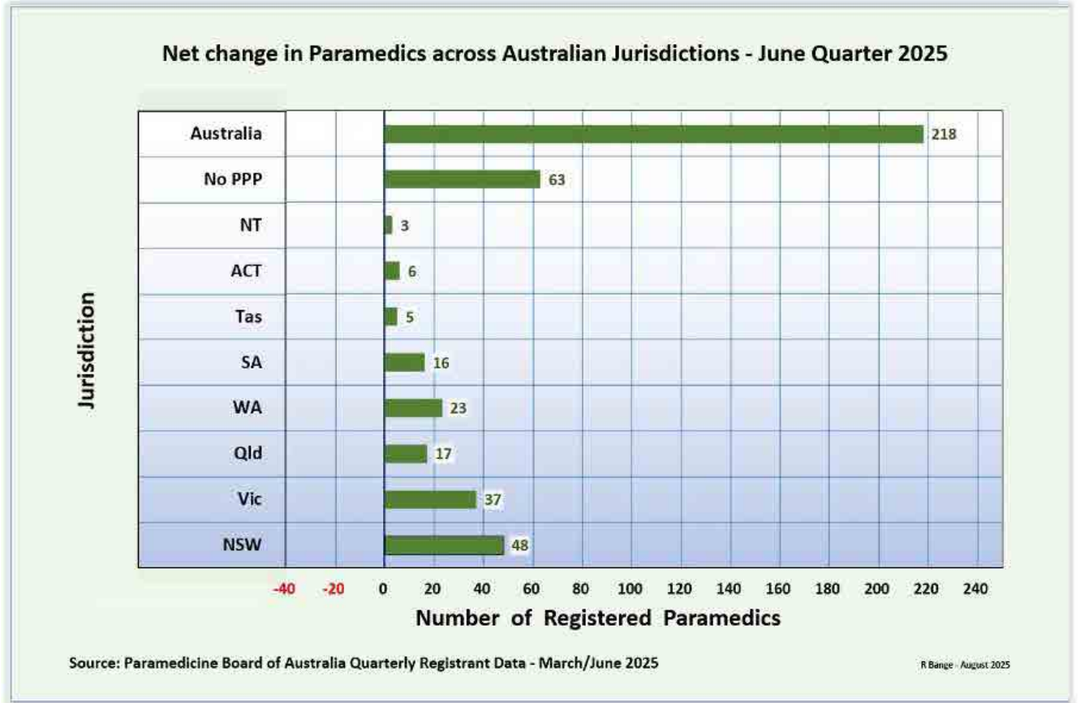
The age profile of the profession shows the impact of significant graduating paramedics in recent years, with 50.6% of paramedics under 35 years of age. The growth in younger paramedics can be seen by comparing the 2025 distribution with the 2020 age profile. The drop-off in numbers in the post-30 age cohort could be seen as a loss to the health workforce (and community).

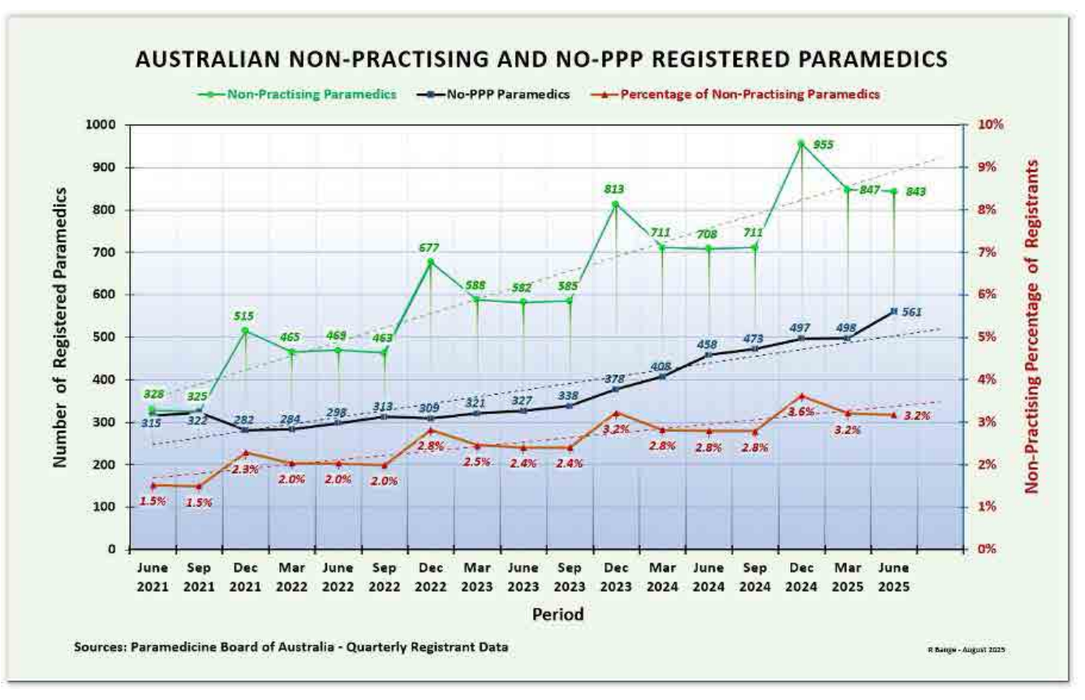
The NT has only 0.20 paramedics for every 1,000 sq km, followed by WA with 0.84.

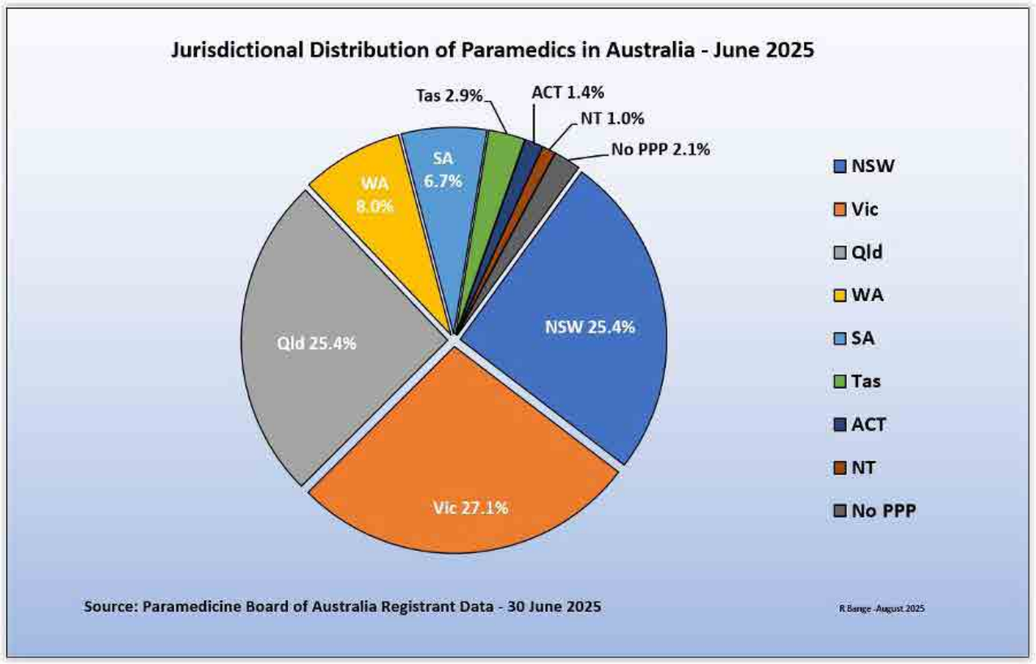


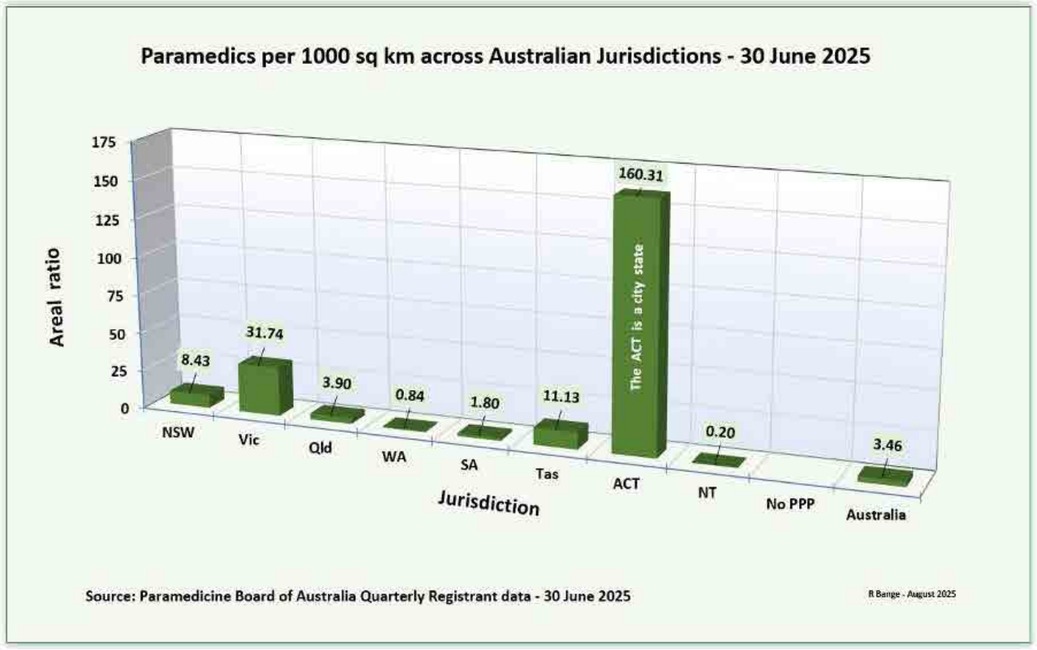

Australian Registered Paramedics for Period June 2022 - June 2025
NSW
Vic
Qld
WA
SA
Tas
ACT
NT
No PPP
Total Registrants
Female Registrants
Jurisdictional Registrants
Number of Registered Paramedics
Period Ending
Jun 2022
Sep 2022
Dec 2022
Mar 2023
Jun 2023
Sep 2023
Dec 2023
Mar 2024
Jun 2024
Sep 2024
Dec 2024
Mar 2025
Jun 2025
23053
23188
23969
23936
24164
24271
25238
25173
25345
25471
26327
26385
26603
10981
11054
11598
11728
11874
11937
12617
12726
12834
12908
13513
13697
13838
Source: Paramedicine Board of Australia - Quarterly Registrant Statistics
R Bonge - August 2025

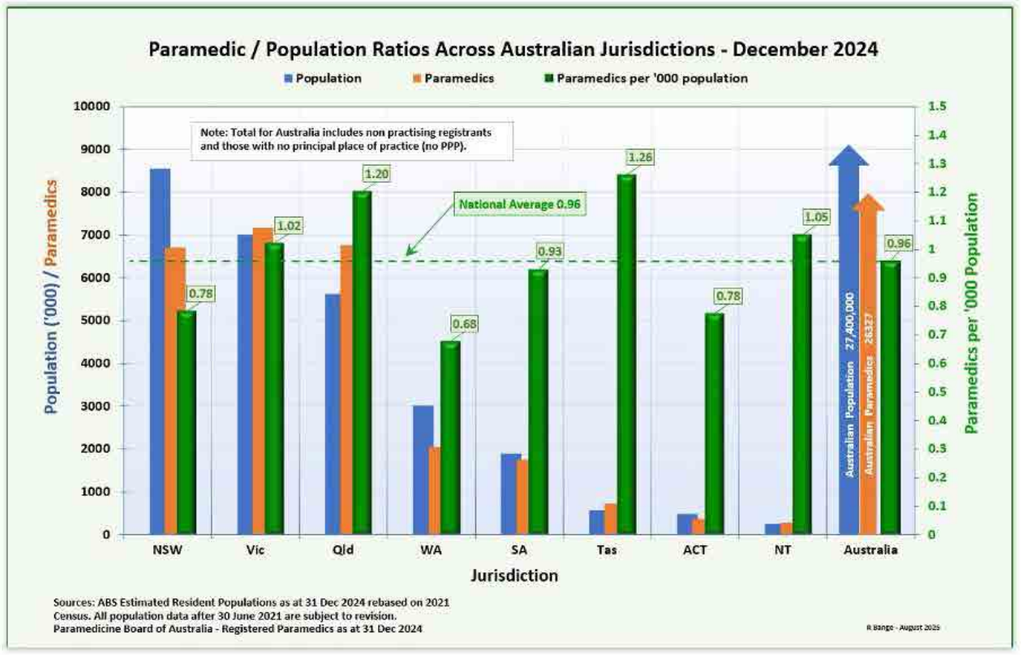

AUSTRALIAN REGISTERED PARAMEDICS AGE PROFILE - JUNE 2025
Registered Paramedics June 2025
Registered Paramedics June 2020
Cumulative Percentage June 2025
Number of Registrants
Cumulative Percentage
June 2020
June 2025
U-25
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80+
Age Group (Year Bands)
5688
5340
3646
2470
1939
2078
1658
952
315
63
10
0
2444
9.2%
30.6%
50.6%
64.3%
73.6%
80.9%
88.7%
95.0%
98.5%
99.7%
100%
100%
100%
Source: Paramedicine Board of Australia Registrant Data - June 2025
R Bonge - August 2025

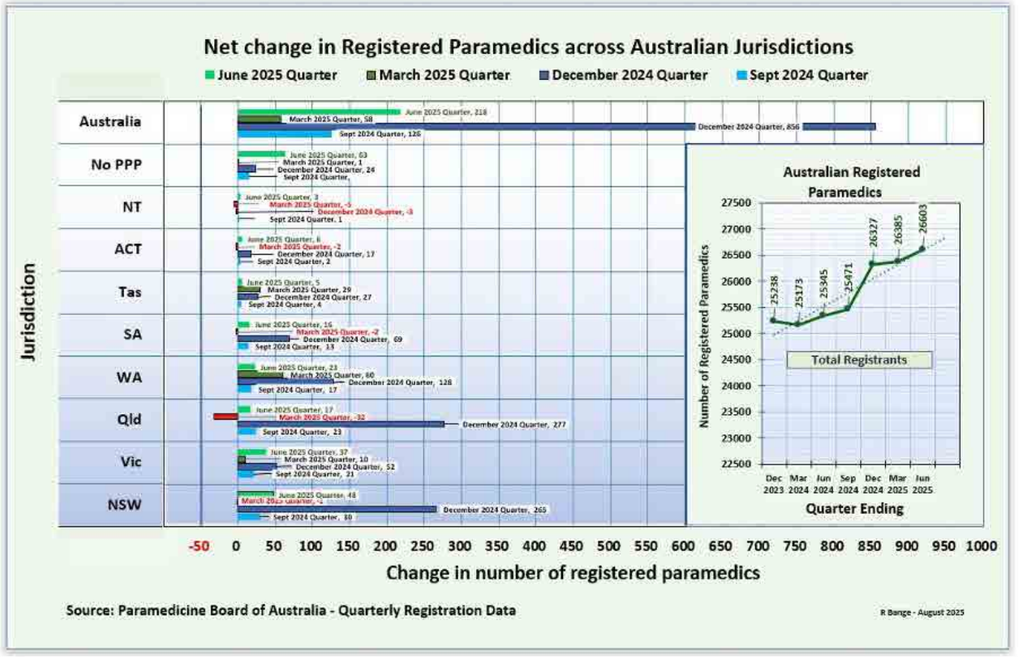

Net change in Paramedics across Australian Jurisdictions - June Quarter 2025
Jurisdiction
Australia
No PPP
NT
ACT
Tas
SA
WA
Qld
Vic
NSW
218
63
3
6
5
16
23
17
37
48
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
Number of Registered Paramedics
Source: Paramedicine Board of Australia Quarterly Registrant Data - March/June 2025
R Bonge - August 2025


AUSTRALIAN NON-PRACTISING AND NO-PPP REGISTERED PARAMEDICS
Non-Practising Paramedics
No-PPP Paramedics
Percentage of Non-Practising Paramedics
Number of Registered Paramedics
Non-Practising Percentage of Registrants
Period
June 2021
Sep 2021
Dec 2021
Mar 2022
June 2022
Sep 2022
Dec 2022
Mar 2023
June 2023
Sep 2023
Dec 2023
Mar 2024
June 2024
Sep 2024
Dec 2024
Mar 2025
June 2025
328
325
315
322
515
465
469
463
677
588
582
585
813
711
708
711
955
847
843
561
1.5%
1.5%
2.3%
2.0%
2.0%
2.0%
2.8%
2.5%
2.4%
2.4%
3.2%
2.8%
2.8%
2.8%
3.6%
3.2%
3.2%
Sources: Paramedicine Board of Australia - Quarterly Registrant Data
R Bonge - August 2025


Jurisdictional Distribution of Paramedics in Australia - June 2025
Tas 2.9%
ACT 1.4%
NT 1.0%
No PPP 2.1%
SA 6.7%
WA 8.0%
NSW 25.4%
Qld 25.4%
Vic 27.1%
NSW
Vic
Qld
WA
SA
Tas
ACT
NT
No PPP
Source: Paramedicine Board of Australia Registrant Data - 30 June 2025
R Bange -August 2025


Paramedics per 1000 sq km across Australian Jurisdictions - 30 June 2025
Areal ratio
175
150
125
100
75
50
25
0
8.43
31.74
3.90
0.84
1.80
11.13
160.31
The ACT is a city state
0.20
3.46
NSW
Vic
Qld
WA
SA
Tas
ACT
NT
No PPP
Australia
Jurisdiction
Source: Paramedicine Board of Australia Quarterly Registrant data - 30 June 2025
R Bange - August 2025


Paramedic / Population Ratios Across Australian Jurisdictions - December 2024
Population
Paramedics
Paramedics per '000 population
Note: Total for Australia includes non practising registrants and those with no principal place of practice (no PPP).
National Average 0.96
Population ('000) / Paramedics
Paramedics per '000 Population
0.78
1.02
1.20
0.68
0.93
1.26
0.78
1.05
0.96
Australian Population 27,400,000
Australian Paramedics 26327
NSW
Vic
Qld
WA
SA
Tas
ACT
NT
Australia
Jurisdiction
Sources: ABS Estimated Resident Populations as at 31 Dec 2024 rebased on 2021 Census. All population data after 30 June 2021 are subject to revision.
Paramedicine Board of Australia - Registered Paramedics as at 31 Dec 2024
R Bange - August 2025


Net change in Registered Paramedics across Australian Jurisdictions
June 2025 Quarter
March 2025 Quarter
December 2024 Quarter
Sept 2024 Quarter
Australia
No PPP
NT
ACT
Tas
SA
WA
Qld
Vic
NSW
Jurisdiction
Australian Registered Paramedics
Number of Registered Paramedics
25238
25173
25345
25471
26327
26385
26603
Total Registrants
Dec 2023
Mar 2024
Jun 2024
Sep 2024
Dec 2024
Mar 2025
Jun 2025
Quarter Ending
-50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000
Change in number of registered paramedics
Source: Paramedicine Board of Australia - Quarterly Registration Data
R Bange - August 2025

Rethinking Ambulance Ramping: A call for safety over politics

Posted 18 August 2025

South Australia's Deputy State Coroner Ian White's recent findings into the deaths of three elderly patients who endured long waits in ambulances before hospital admission were critical of the obsession with ramping figures.

He criticised the "fixation" by the media and some clinicians on eliminating ramping, stressing that every strategy to date had been "swallowed" by the ever-increasing demand on the health system, including an increase in beds. His report also documents the many initiatives that have been introduced to alleviate ramping. https://tinyurl.com/3fvpdfs9

The Observer participated in an earlier South Australian Legislative Review Committee (LRC) study of the Ambulance Service, which published its Final Report on the South Australian Ambulance Service Resourcing here: https://tinyurl.com/2rdw2y4f

The Observer acknowledges that there have been significant developments in funding and staffing since the LRC review was initiated, and change remains underway. He agrees with Coroner White's message that ramping is unlikely to ever be completely eliminated, but we can and must make it safer.

The problem with fixating on ramping

For years, governments, media, and clinicians have been locked in a cycle of outrage over rising ramping statistics. But as Coroner White warns, this obsession hasn't solved the crisis—it's tended to deepen divisions while not fully addressing the real issue: patient safety.

Two lives might have been saved

The coroner found that Graham Jessett (64) might have survived if a simple blood test had been done while he waited in the ambulance. His fatal cardiac arrest was linked to undiagnosed hyperkalaemia—a reversible condition. Bernard Skeffington (89) likely would have lived if a nasogastric tube had been inserted earlier for his bowel blockage.

Yet, instead of focusing on practical safety measures, the system remains fixated on what Coroner White calls the unrealistic goal of eliminating ramping entirely.

"Like telling a trapeze artist not to use a net"

The Coroner's analogy hits hard: refusing to improve safety for ramped patients because we "hate ramping" is like telling a trapeze artist to just "get better" instead of using a safety net. We need both, efforts to reduce ramping and policies to protect those who wait.

What Needs to Change? The Coroner suggests:

- Blood tests for ramped patients – Identifying hidden critical conditions before it's too late.

- Emergency protocols for deteriorating patients – Including emergency buttons in ambulance waiting areas.

- Better discharge policies – Reducing weekend bottlenecks caused by limited specialist availability.

- Cultural shift – Accepting that ramping is a reality and focusing on harm reduction.

The bottom line

Ramping is a symptom of a strained health system—one that won't be fixed overnight. But while we work on long-term solutions, we cannot abandon patients to unnecessary risks. As Coroner White warns, the system is "tearing itself apart" over politics instead of prioritising lives.

It's time to shift the conversation from "How do we end ramping?" to "How do we reduce ramping and keep patients safe while they wait?"

Read the full coroner's report: [2025] SACC 21: https://tinyurl.com/mryrz29m

Recommendations as a Flipbook: https://online.fliphtml5.com/eeyoy/jlym/

Tasmanian election pledge to introduce paramedic practitioners

Posted 4th July 2025

As we approach the Tasmanian election on 19 July, the Rockliff Liberal Government is doubling down on its commitment to a stronger, more innovative health system if reelected. https://tinyurl.com/y5hrrymp

Over the past decade, several inquiries have been held into the health system in Tasmania. These have spurred investment in major hospitals, expanded emergency departments, and increased the attention given to primary care and the ambulance service. https://tinyurl.com/5zwr44ff and https://tinyurl.com/5zwr44ff

Current Premier Jeremy Rockliff has announced the Liberal Party's intention (if in government) to introduce Paramedic Practitioners—empowering them to prescribe medications and treat patients at home, potentially reducing ambulance transfers and Emergency Department pressures. https://tinyurl.com/2uj36cff

In addition, if elected, the Liberals promise to invest in Nurse Practitioners through scholarships and rural incentives, ensuring Tasmanians get faster, closer care at home for chronic and acute conditions.

Among the key issues discussed by the Tasmanian Rural Health Inquiry (and others) was the appointment of a Chief Paramedic Officer for the State. There's no mention of that in the current policy statement, but Premier Rockliff is well aware of the importance of such a position, which was raised in submissions and discussed with him during the public hearings of the Inquiry. https://tinyurl.com/mk9uzs3a

Kings Birthday Honours 2025

The Ambulance Service Medal (ASM) and Medal of the Order of Australia OAM

Medal of the Order of Australia OAM

Ambulance Service Medal

AMBULANCE SERVICE MEDAL (ASM)
For distinguished service as a member of an Australian ambulance service.

NEW SOUTH WALES
Shireen DOYLE

Ms Shireen Doyle joined NSW Ambulance in January 1990. In the last 35 years she has served in a range of frontline and operational roles within metropolitan sectors including her current role of intensive care paramedic. She has previously served as a station officer, station manager, duty operations manager, clinical training officer and paramedic educator. Ms Doyle is also currently the clinical training officer within the Western Sydney Nepean Blue Mountains Continuing Education Unit.

Ms Doyle was instrumental in designing and implementing the Buddy Program, a support initiative matching new or relocating staff with experienced employees to facilitate smoother transitions and provide additional peer-based support. This program has fostered a culture of care, enabling paramedics to thrive in their roles and environments.

Ms Doyle conceptualised and implemented the Labour of Love program in collaboration with the Nepean Hospital Birthing Unit. This initiative provides paramedics with clinical training experience, pairing them with experienced midwives for a shift to enhance paramedics' capabilities in managing maternal emergencies in pre-hospital settings. This resulted in the establishment of a five-year memorandum of understanding, enabling reciprocal training opportunities for midwives to engage with paramedic on-road and airborne operations. The program has since been expanded to other areas of the state, including Westmead Hospital, with Ms Doyle playing a pivotal role in this expansion. To date almost 400 paramedics have benefitted from participation in the program, and it has been recognised in local industry awards for its exceptional impact and innovation.

Ms Doyle's contributions have significantly advanced paramedic training and support systems, while her leadership and dedication have inspired colleagues to strive for excellence. Ms Doyle exemplifies the highest standards of selflessness, compassion, and professional excellence. Her remarkable 35-year career serves as a testament to the extraordinary impact one individual can have in the service of peers and the community, embodying the core values and ideals of NSW Ambulance.

Michael RICHER

Mr Michael Richer joined NSW Ambulance in February 1998. In the last 27 years he has served in a range of frontline and operational roles within metropolitan sectors including intensive care paramedic, station officer, duty operations manager and educator within NSW Ambulance and universities. He has also undertaken associate director and acting director roles in clinical operations, control centres and clinical education. As well as being an intensive care paramedic, Mr Richer is also currently the associate director of Clinical Education based at the NSW Ambulance State Operations Centre (SOC).

Mr Richer has led clinical education through a period of significant change and reform. Illustrated by his role in the modernisation of clinical education at the NSW Ambulance SOC, implementing new training facilities and the expansion of clinical simulation befitting of a modern adult learning environment reflective of community expectations of frontline clinicians.

Through the height of the COVID-19 pandemic Mr Richer was responsible for adapting and maintaining delivery of clinical education whilst keeping staff safe during a rapidly evolving public health emergency. He met the challenge of consistently developing and implementing strategic and tactical responses to the many and varied challenges which arose. He was pivotal in the design and implementation of the post-employment tertiary pathway program and facilitated the increase in paramedic specialists and specialist courses across the state during the pandemic. Mr Richer was a key player in developing and implementing this sustained high-volume onboarding strategy for hundreds of additional clinical staff delivered through the Strategic Workforce Infrastructure Team program.

Mr Richer has demonstrated distinguished service throughout his NSW Ambulance career, in a range of operational roles, nurturing future generations of frontline clinicians through his commitment to clinical education. He has aided in the protection of the community through leading NSW Ambulance education clinical response to a range of complex incidents, at times involving significant personal sacrifice or risk to himself.

QUEENSLAND
Patrick BROWN

Mr Patrick Brown commenced his distinguished career as cadet ambulance officer on 17 April 1979 with the former Queensland Ambulance Transport Brigade and is currently the officer-in-charge at the Ingham Ambulance Station. Mr Brown leads by example and exemplifies the core values of the Queensland Ambulance Service (QAS).

Mr Brown has an extensive history spanning 45 years of service on the road for the QAS, especially in rural communities, and has attended numerous and varying traumatic incidents. He often responds to these incidents as a single officer or as forward commander, including an incident in 2008, when a Tilt Train and B- double truck collided. The incident involved 81 passengers, 7 train crew and the truck driver. Mr Brown provided an exemplary level of leadership during the multi-casualty incident. Most recently, he responded to a significant vehicle accident in an isolated area in Queensland, as a single officer.

Mr Brown is the cornerstone of the Ingham Ambulance Station and has built strong relationships within his community. As a QAS peer support officer chaplain, he is a trusted and respected confidant to his peers and ensures their welfare and safety by often travelling to stations across the region to provide support to staff who are often isolated. He also offers support to fellow emergency services officers who have attended critical incidents alongside QAS.

Mr Brown is a core member of the Hinchinbrook Local Disaster Management Group and holds a fundamental role in assisting his community during the many natural disasters experienced by the community, including multiple cyclones and floods. His local knowledge of at-risk communities has been vital to the deliberations of public safety and welfare during disaster response and recovery.

Mr Brown's ability to lead and mentor with enthusiasm and grit, as well as his dedication to QAS and his community makes him a valued and respected member of the service and the Queensland community.

Peter HERON

Mr Peter Heron has dedicated almost 30 years to serving in rural and remote locations as an advanced care paramedic and is currently an acting officer-in-charge with the Queensland Ambulance Service (QAS). In this role, he is a highly trained clinician and consistently demonstrates exceptional leadership, achieving the best outcomes for patients and colleagues, even in the most challenging circumstances.

Mr Heron is a proud Indigenous man who has worked in various rural communities for QAS; during this time responding to multiple cyclones,

Continued >

floods and incidents, including a bus crash near Ayr in 2000. In 2004, Mr Heron was deployed to the Palm Island riots following significant community unrest due to the death in custody of an Indigenous resident. His exemplary leadership and commitment to the Palm Island community ensured the welfare and safety of QAS officers and continuation of ambulance service delivery within the community.

Mr Heron is committed to the wellbeing of colleagues as a peer support officer actively involved in the Priority One's Aboriginal and Torres Strait Islander Support Service, providing culturally specific advice and support to colleagues. He represents QAS at Indigenous events and is an Indigenous liaison officer, contributing to the Aboriginal and Torres Strait Islander leadership committee. He also plays a crucial role in selecting and educating officers for the Indigenous Paramedic Program.

In addition to his outstanding record of work with QAS, Mr Heron works tirelessly to support his local community including volunteering for the Burdekin area youth watch, which provides support for vulnerable youth in the community. He is also a proud member of the Ayr and Home Hill Health Services advisory committee, which focuses on improving Indigenous health across the Burdekin community.

Wayne KIRK

Mr Wayne Kirk commenced his career with Queensland Ambulance Service (QAS) in 1998 and has attained the level of critical care paramedic. Throughout his 27-year career, Mr Kirk has been in operational frontline roles providing outstanding patient care to his community. He has provided exemplary care in critical care emergencies and high-pressure situations demonstrating exceptional decision making by maintaining composure and focusing on excellence in patient outcomes.

Mr Kirk makes a significant impact on communities by focusing on broadening his networks to ensure various community groups work together to achieve positive results. He has a rich background in frontline mentoring and coaching for all staff and advocates for the teams he leads, the community he provides services for, and continuous improvement to ensure excellence in ambulance services. He currently leads not only the paid QAS workforce, but the first responders and volunteers in building their capability and involvement in supporting their communities with frontline operational support.

In 2021, Mr Kirk selflessly assumed the role of forward commander, providing exceptional leadership and expert emergency management during the Inglewood flood emergency. He was exceptional in stakeholder engagement, liaising with members of other emergency services and local disaster management officials, providing expert advice and guidance.

Mr Kirk embodies the characteristics of an outstanding frontline leader, who leads with integrity through his actions consistently providing unwavering safe, supportive, and encouraging workplace that emulates courage, selflessness, and teamwork. He is an outstanding officer with integrity and courage, who continuously and tirelessly dedicates his time to improved outcomes for his workforce, volunteers and patients in the communities he serves.

Ian TARR

For over 34 years, Mr Ian Tarr has undertaken operational frontline roles across the Queensland Ambulance Service (QAS) in support of the organisation's vision to deliver excellence in ambulance services, maintaining his credentialled scope of clinical practice whilst working as a registered paramedic. Mr Tarr has provided emergency response to individual patients, acted as a frontline supervisor at various stations and an operations supervisor, providing an emergency response capability across multi-casualty and high-risk operational incidents. He has enhanced community resilience through volunteer training and community education and improved service delivery across communities to ensure prevention, preparedness, response and recovery activities were implemented.

Mr Tarr has provided support to the QAS commissioner and chief operating officer during multiple disaster seasons, including the recent 2023-24 high risk weather season, including cyclones and flooding in Far North Queensland, and destructive storms throughout the Gold Coast region. Mr Tarr provided high level direct system support and leadership throughout the COVID-19 pandemic, in numerous frontline capacities where his knowledge and experience ensured the QAS continued operational service delivery despite the significant and sustained impacts. He was also an integral part of the success of the QAS response to the Gold Coast 2018 Commonwealth Games, ensuring the provision of ambulance services to the games and the wider community.

Mr Tarr is a well-respected officer of the QAS who has personally led and delivered multiple service delivery improvements, focusing on improved ergonomics and enhanced patient care for all Queenslanders. These improvements include the redesign and implementation of QAS primary response kits; new service delivery models of care, service initiatives, and increased disaster management response capability; and service

enhancements to the QAS emergency management unit to support local community preparedness and response during disaster and mass casualty incidents.

WESTERN AUSTRALIA
Shane TOOVEY

Mr Shane Toovey joined St John Ambulance Western Australia in 2010 as an on-road ambulance officer. He was promoted to paramedic in 2012 where he served in the metropolitan area. In 2018 he took on the regional community paramedic role serving the Meekatharra and surrounding community for two years.

Mr Toovey's demonstrated exceptional clinical skills and leadership ability saw him rise to the level of area manager and in 2021, clinical support manager. Mr Toovey has had extensive experience with extremely confronting scenes, including solo responding to high trauma cases where the stress of inability to transport the patient increases the cognitive burden.

Mr Toovey has maintained a supportive and mentoring attitude to those he has worked with and has continued to dedicate himself to the development of his peers and juniors to maintain the highest standards of care to all the people of Perth. Mr Toovey's roles as a clinical support paramedic have allowed him to develop policies and procedures for his fellow clinical support paramedics and pass his knowledge and expertise onto the next generation of paramedics privileged to work alongside a paramedic as dedicated as him.

Mr Toovey has had an extensive history of responding as a clinical support paramedic as both a supporting role to crews and being the solo responder first on scene. Notably, Mr Toovey has had notable responses to cases of significance, including attending to a fallen service member and to a case where, knowing the high risk, he made the decision to enter the scene in an attempt to save an individual's life.

Mr Toovey has attended as the first solo responder on scene and managed to a degree not expected of even an experienced crew. One such case involved an elderly man who was struck from behind while riding a bike, the driver fleeing the scene. This case occurred without the critical care paramedic resource being available and he was able to effectively manage this patient with all interventions, including securing the patient's airway via intubation and continuing to support the patient's ventilations. Mr Toovey's practices are celebrated by his peers.

SOUTH AUSTRALIA
Tracey BELLAMY

Ms Tracey Bellamy commenced with SA Ambulance Service (SAAS) on 20 June 2011 becoming a highly valued member of the Meadows Team (Country Regional Response Team and Southern Adelaide Regional Response Team) as an ambulance officer. Ms Bellamy became the volunteer team leader for the Meadows Team in 2016, a position she still holds currently. In 2019, Ms Bellamy joined the SAAS Volunteer Health Advisory Committee and in 2023, she was appointed as its presiding member. In 2021, Ms Bellamy became a member of the local zone ambulance coordinating committee for her region.

Early in her volunteering journey, Ms Bellamy was identified as a key contributor to whichever team she was volunteering with. It was also obvious that Ms Bellamy had a passion for patient advocacy and compassionate patient care. The progression into her leadership roles was a natural pathway while she developed expertise as an ambulance officer.

Ms Bellamy has worked tirelessly towards improving the flow of communication between volunteers, SAAS Executive Leadership Team, and the Government of South Australia. Ms Bellamy worked on the SAAS volunteer training resource project to advocate for volunteers and ensure allocated funding and resources were directed towards training uptake and volunteer retention.

Ms Bellamy is entrenched in the Adelaide Hills community and has been effective in raising the SAAS volunteer profile in this region. Through her involvement in community events such as fetes, or training alongside other local emergency services such as Country Fire Service, she has represented SAAS impeccably.

Ms Bellamy has made a significant contribution towards the health and wellbeing of local communities across SA since commencing as a volunteer over 13 years ago. Through leadership and as a spokesperson, Ms Bellamy has had an impact upon the skills, training and confidence required by SAAS volunteers to deliver excellent emergency treatment and transport of locals in their communities.

Continued >

Leigh NICOLSON

Mr Leigh Nicolson has been delivering ambulance services to the South Australian community since 1988, as a paramedic with SA Ambulance Service (SAAS), a leader in its busy Emergency Operations Centre (EOC) and a volunteer ambulance officer. Mr Nicolson is currently operations manager of the EOC, the nerve centre of the ambulance service where over 870 Triple Zero (000) calls are received every day and ambulance resources are deployed to assist South Australians in their hour of need.

Mr Nicolson is widely respected as a natural leader, guiding staff with clarity and compassion even in the most demanding circumstances like the collapse of a showground ride which injured 37 people at the 2000 Royal Adelaide Show. Mr Nicolson played a central role in managing the incident to ensure rapid deployment of ambulance resources.

During the COVID-19 pandemic, Mr Nicolson stood out in the way he supported his team to be adaptable and resilient as the ambulance dispatch and patient care models changed frequently.

As a leader and manager, Mr Nicolson has made a lasting impact through his contributions to service delivery improvements and the training of EOC staff to uphold operational excellence. In addition to his demanding management role, Mr Nicolson also serves his community as a volunteer ambulance officer in the Adelaide Hills.

With over 37 years of exemplary service to the South Australian community, Mr Nicolson has demonstrated an unwavering commitment to patient care and operational excellence, underpinned always by his empathy for SAAS patients and staff.

AUSTRALIAN CAPITAL TERRITORY

Lisa DECK

During her 27-year career with the ACT Ambulance Service, Mrs Lisa Deck has consistently demonstrated exceptional clinical and operational leadership in the provision of pre-hospital clinical care to the ACT community. Her career is complemented with a sustained dedication and commitment to patient centred care and clinical excellence both operationally and in supporting roles. As a training and development officer, Mrs Deck has supported the clinical development and proficiency of newer members of the ACT Ambulance Service, whilst maintaining her own operational capacity. In doing so, she has supported the enhancement of the pre-hospital clinical services provided to the ACT community.

Mrs Deck has played a key role in the development and implementation of a new roster initiative for the ACT Ambulance Service. This transformational change promotes better fatigue management; quarantines time for paramedics to hone and perfect their clinical skills; supports professional registration requirements for paramedics and organisational accreditation goals; and more broadly improves welfare outcomes for paramedics within the ACT.

The implementation of a secondary triage system was a key initiative to support an improved patient experience and clinical outcomes for those coming into the care of the ACT Ambulance Service. Mrs Deck has played a key role in the operationalisation of this system and its introduction within the ACT Emergency Services Agency Communications Centre.

Mrs Deck is a respected leader within the ACT Ambulance Service. She has been a consummate professional, committed to the highest ethical and professional standards expected of a paramedic.

Her personal values and behaviours reflect a collaborative and humble leader, and she is a female role model for all members of the ACT Ambulance Service. Mrs Deck is driven to deliver high quality patient centred care in every role she has fulfilled and actively seeks opportunities to improve the pre-hospital emergency services available to the ACT community.

MEDAL OF THE ORDER OF AUSTRALIA (OAM) IN THE GENERAL DIVISION

Michael Barrenger, Tasmania

For service to the community of George Town.

Ambulance Tasmania

• Volunteer Ambulance Officer, Launceston, 1975-1977.

• Paramedic, Launceston, 1977-1984.

• Intensive Care Paramedic, George Town, 1984-2021.

• Former Exchange Program Officer, Singapore.

• Former Exchange Program Officer, United States of America.

• Former Mentor. • Former Trainer, George Town Volunteer Ambulance Service.

• Former Fundraiser, George Town Ambulance Service.

Other Emergency Services

• Former Member, Volunteer Ambulance Officers Association of Tasmania.

• Former Member, George Town Unit, State Emergency Service.

George Town Sub-Branch, Returned and Services League of Australia

• Former Supporting Paramedic, ANZAC and Remembrance Events.

• Member, current. Service Groups

• Assisted with re-establishment, Apex George Town.

• Member, Rotary Club George Town, 1992-2000.

Awards and Recognition includes:

• Community Citizen of the Year, George Town, 2021.

• Northern Region Emergency Services Worker of the Year, Returned and Services League of Australia Tasmania, 2020.

• National Medal, 1991; 1st Clasp (25 years), 2000; 2nd Clasp (35 years), 2011; 3rd Clasp (45 years), 2021.

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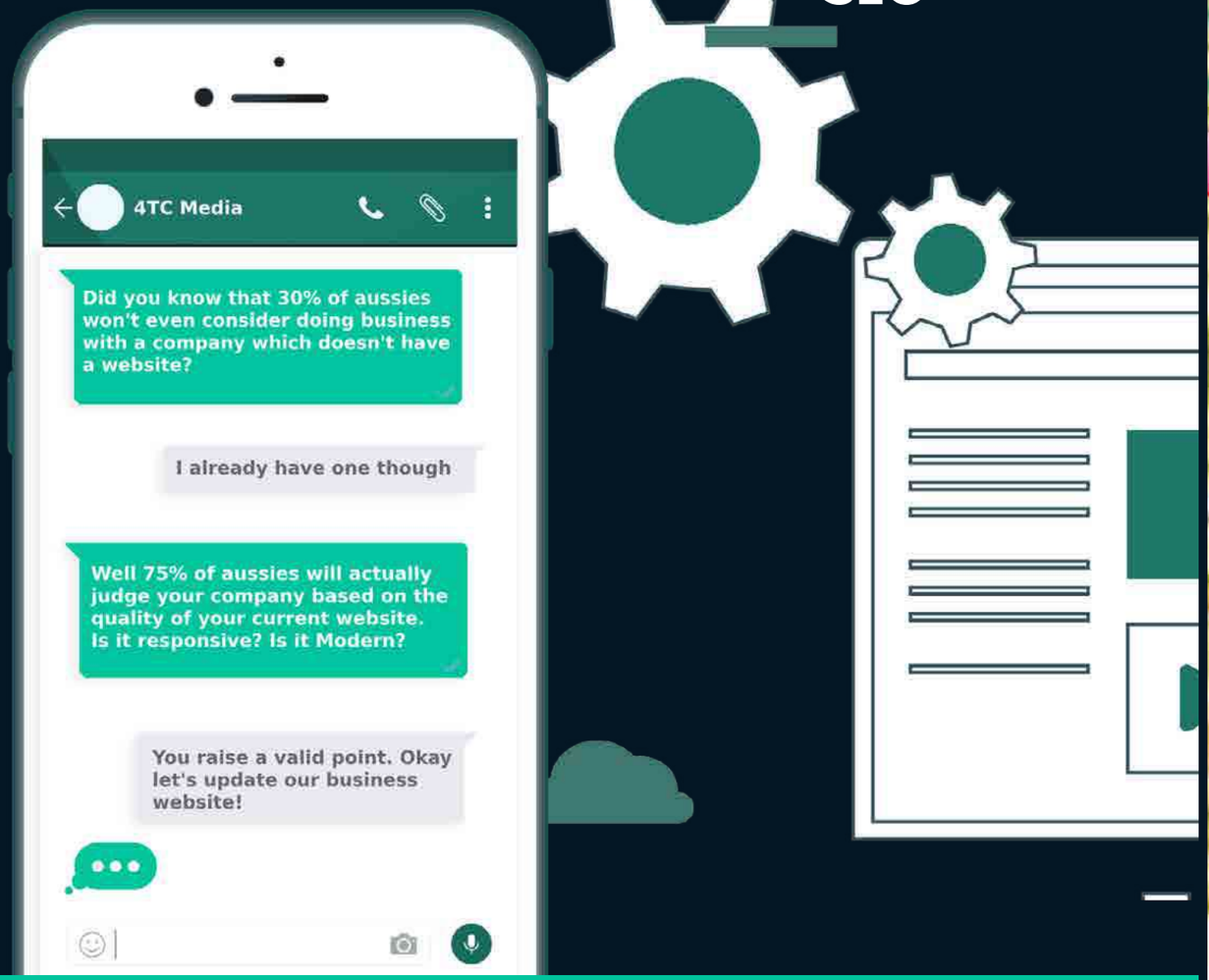

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FOAMed HIGHLIGHTS

EMCrit — "Serotonin Syndrome and Neuroleptic Malignant Syndrome" (Podcast, Apr 2025)

This EMCrit podcast and show notes break down recognition and management of two rare but life-threatening conditions paramedics may encounter: serotonin syndrome and NMS. Emphasis is placed on rapid bedside recognition, key physical exam findings, and prehospital stabilisation considerations (sedation, airway support, cooling).

See more: **https://emcrit.org/emcrit/ss-vs-nms/**

EMCrit — Massive hemorrhage protocol

EMCrit's Resuscitation and Acute Critical Care (RACC) literature reviews summarise the most impactful new research in critical care and resuscitation. For this edition the focus is treatment of massive hemorrhage, not just trauma, but also OB with post-partum hemorrhage and GI bleeds. They look at massive transfusion protocols and all the stuff that goes with them. Plus they go over the Eight "Ts" of Massive Hemorrhage Protocols, with a special emphasis on rural centers.

See more: **https://emcrit.org/emcrit/massive-hemorrhage-protocol-2/**

FOAMed

FOAMed HIGHLIGHTS

RCEMLearning FOAMed Roundup — August 2025

Covers guideline updates and frontline practice tips, including atrial fibrillation management, ACS rule-out strategies, and ED systems learning. Paramedics can adapt much of this knowledge to improve triage, referral, and safe handover. Show notes and learning resources are free.

See more: **https://www.rcemlearning.co.uk/foamed/august-2025/**

RCEMLearning Podcast — June 2025

This modular podcast blends case discussions, expert interviews, and CPD questions. June's episode includes airway troubleshooting, paediatric pearls, and toxicology. The format suits paramedics doing personal study or group learning during downtime.

See more: **https://www.rcemlearning.co.uk/modules/rcemlearning-podcast-june-2025/**

Prehospital Paradigm Podcast — "Do No Harm" Discussion

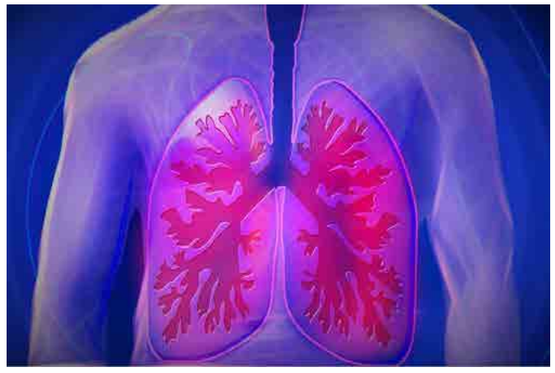
This EMS-focused podcast (University Hospitals EMS, US) covers a variety of topics. This series has a focus on "Do No Harm" and the discussion of drug abuse patients and their treatment. The challenge of stigmatizing of these patients is significant but this discussion reveals that there is stigmatization that goes on within the drug use patient community too.

See more: **https://www.prehospitalparadigm.com/podcast**

Management of Severe Sepsis and Septic Shock — Review (Mar 2025)

A detailed, open-access update with bedside reference guides. Includes resuscitation bundles, updated fluid recommendations, and emerging therapies. Provides visual flowcharts and clinical pearls that can be adapted for paramedic quick-reference.

See more: **https://link.springer.com/article/10.1007/s40138-025-00305-0**



Evidence-Based Guideline for Prehospital Airway Management (AHRQ, 2025)

Comprehensive open-access guideline with evidence tables, recommendations, and "good practice" statements. Covers BVM, supraglottic devices, intubation, and surgical airways, emphasising prehospital applicability. Indispensable for protocol development, training, and continuing education.

See more: **https://www.ems.gov/assets/Evidence-Based-Guideline-for-Prehospital-Airway-Management.pdf**

Continued >

FOAMed HIGHLIGHTS

EMS Airways Series: The Ventilator, part 1 (YouTube, 2025)

Step-by-step procedural videos focusing on advanced airway skills, such as surgical cricothyrotomy and preparation techniques. Provides clear demonstrations with commentary suitable for individual paramedics or training days. This particular session focuses on patients on a ventilator

See more: **https://www.youtube.com/watch?v=MaJ7AwSLFWU&list=PLx2n570BrznT2t2pucNYrVQ5d26GX3EZT&index=22**

Rich Levitan — "The Surgical Airway" (TBS Zermatt Lecture, Aug 2025)

World-renowned airway expert Dr. Rich Levitan shares key principles and pitfalls of surgical airway management. Recorded at TBS Zermatt, this lecture is freely available and provides advanced insights valuable for critical care paramedics and educators.

See more: **https://www.youtube.com/watch?v=bASNBsV5frg**

Heavy Lies the Helmet — Episode 130: "Opinion-Based Medicine w/ Mike Carunchio"

A more reflective podcast episode that discusses how opinion (rather than evidence) still shapes much of EMS practice. Good listening for paramedics to audit their own practices: which parts are evidence-based vs habit/opinion, and how to challenge or justify them.

See more: **https://heavyliesthehelmet.com/foamed/**

The medic's sleep manual: How to overhaul your bedroom for better rest

EMS1 Videos

EMS1's video resource centre offers a wide range of video content: case-analysis, training, procedural demonstrations, leadership, clinical updates. Highlighting a recent review of paramedic sleep and identifying ways to improve sleep and fight fatigue.

See more: **https://www.ems1.com/video**

AUSTRALIAN PARAMEDIC

Writing an article for Australian Paramedic

Australian Paramedic welcomes articles from paramedics across Australia and internationally – you too can become a part of this exciting new journal!

We welcome articles on any of the following:

- Clinical review, report or discussion;
- Case study;
- Management in emergency medical services;
- Occupational health and safety;
- Opinion pieces;
- General health, psychology or law relevant to emergency medical services;
- Any other article or knowledge that you would like to share that is relevant to the Australian Paramedic.

Lead authors of published articles will be paid for their submission. Payment amount will vary depending on type of article, length, and inclusion of images. Payment will also be considered for submission of images, independent of any article, but it is up to the photographer to ensure that all relevant permissions are sought.

Getting published in Australian Paramedic

DO YOUR HOMEWORK

The key to having your article published is to do your homework first, and ensure your writing is targeted to our journal. Knowing the target audience is imperative, and an essential first step. For us, we are looking for articles with good content and information relevant to paramedics in Australia.

This does not mean we will limit our information only to Australian content... far from it. There is also a lot to learn from methods and processes used internationally, and we will endeavour to include such information in our journal too. What we do want is current information that provides updates relevant to emergency medical care.

DISCUSS WITH THE EDITOR

Discussing ideas and proposals with the Editor can be a great way to ensure that you do not waste your time. Our Editor is very happy to receive enquiries and provide advice on an approach for an article or identifying areas of key interest for our journal. All you have to do is drop a line or two to *amy@ausparamedic.com.au*

GRAB THE READER'S ATTENTION

It is essential to grab the attention of the reader in the first paragraph of the article – by providing a catchy phrase, or simply giving an interesting snippet of what your article will be talking about. After that, good flow, grammar and punctuation is essential as well, to keep our readers engaged.

PROVIDE SOME GREAT PHOTOS

Photos also are a great way to grab attention, and they make up a crucial part of articles in our journal. Photos can be submitted as separate files, with ideally a resolution of at least 300dpi. However, it is up to you to ensure you have the permission of people appearing in the photo for publication.

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