

WHERE HUMANITY GOES, MEDICINE MUST FOLLOW

A COMPREHENSIVE GUIDE TO EXTREME MEDICINE

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INTRODUCTION

We live in a world where change is constant. The challenges are existential and looming not in the far future but in the near, a clear and present danger to human health. This is a challenge for the medical profession, the like of which we have never seen. The clarion call is faint but growing - the call requiring innovators and medical professionals with the ability to take medicine outside the hospital walls and into low-resource environments, to problem-solve, bringing to bear a multidisciplinary approach gelled by good leadership and team membership; in short, extreme medicine.

'It's the exciting part of medicine' Dr Tim Nutbeam, Editor, ABC of Prehospital Emergency Medicine.

When we initially established World Extreme Medicine (WEM), we did so in an environment where the links between expedition, disaster & humanitarian, tactical, sports and space medicine were

few and protected by silos. We have sought to break down these barriers by creating a community where experiences and networks are shared openly, opportunities for new research are made, and conversations on how to approach extreme medicine differently are stimulated.

The Lancet described the field as such:

'Extreme, expedition and wilderness medicine are modern and rapidly evolving specialities that address the spirit of adventure and exploration. The relevance of and interest in these specialities are changing rapidly to match the underlying activities, which include global exploration, adventure travel, and military deployments. Extreme, expedition, and wilderness medicine share themes of providing the best available medical care in the outdoors, especially in austere or remote settings. Early clinical and logistics decision-making can often have important effects on subsequent outcomes. There are

lessons to be learned from out-of-hospital care, military medicine, humanitarian medicine, and disaster medicine that can inform in-hospital medicine and vice-versa. The future of extreme, expedition and wilderness medicine will be defined by both recipients and practitioners and empirical observations will be transformed by evidence-based practice'

This specialised field of healthcare, which involves providing medical care in the most austere and challenging environments, plays an increasingly pivotal role in our global society.

Extreme medicine, encompassing care not only in an expeditionary environment but also in disaster & humanitarian settings in conflict zones, Sports Medicine and Psychology, and indeed in Space Medicine, is crucial because it advances medical practices under harsh conditions, enhances emergency preparedness, and improves survival rates in critical scenarios. It pushes the barriers to remote

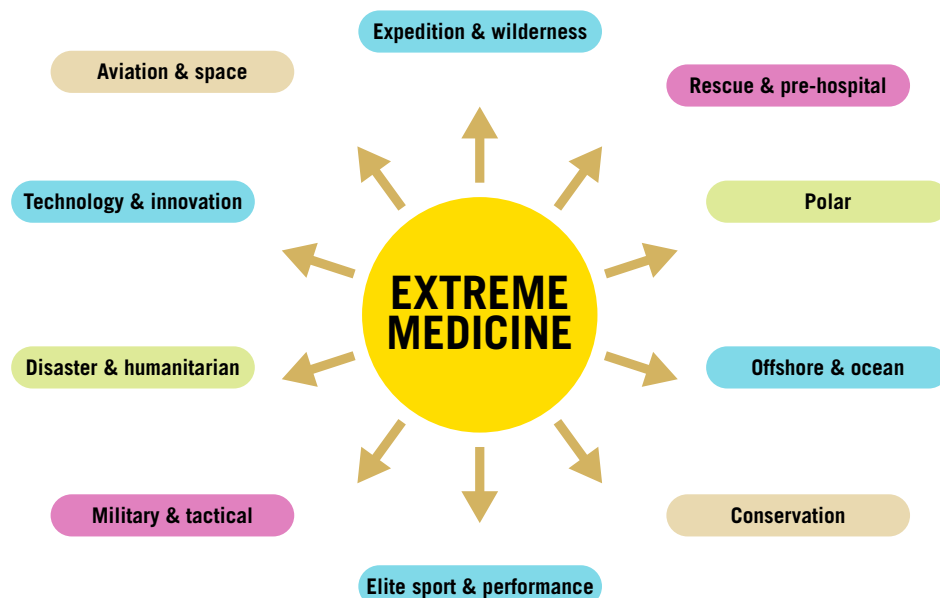


Figure 1: The many different facets of extreme medicine, of which elite sport and performance is one.

healthcare innovation, benefiting broader medical fields while ensuring vulnerable populations receive critical care when and where it's most needed.

EXTREME MEDICINE STANDS ON THE SHOULDERS OF GIANTS

Its origins can be traced back to ancient times. The professional military medics or 'Medicus' of Roman armies were supported by Capsaicin, who carried bandages ('fascia') in their 'capsae', or bags, supported by rescuers paid by the number of men they rescued.

The Renaissance saw renewed interest in studying anatomy, surgery, and medicine, leading to advancements in military medical practice. Military surgeons developed new techniques for treating battlefield injuries, such as amputations, wound debridement, and fracture management. In 1537, Ambroise Pare, a French barber-surgeon, was sent to the Siege of Turin. Appalled by the blood loss among the casualties, he followed in the footsteps of Islamic and Roman medics before him, who used a technique that had been long forgotten until the Renaissance. He began fashioning ligatures tied near their wounds, a painful but effective method to reduce blood loss.

Napoleon's Grande Armée Surgeon General Dominique Jean Larrey developed the concept of 'ambulances volantes' ('flying ambulances') after noting

how his general could move his artillery pieces around the battlefield. Replace the cannon with a stretcher, and you have the first ambulance. Train a corps of equipped soldiers, infirmiers tenues de service, and you have the first paramedics. Larrey noted that during the retreat from Moscow, a disproportionate number of officers suffering extensive tissue damage and realised that the thawing of frostbitten tissue by campfires, which officers had closer access to, only worsened the injury.

During the American Civil War, musicians were used as stretcher-bearers - not unlike conscientious objectors during World War One - to carry the casualties to field hospitals. They sometimes applied basic first aid on the way. However, the results were mixed, leading to Surgeon-Major Jonathan Lett creating the first U.S. Ambulance Corps as an integral part of the Union Army in September 1862.

EXTREME MEDICINE IS NOT FOR THE FAINT-HEARTED

In 1961, isolated in an Antarctic Winter, Russian surgeon Leonid Rogozov became seriously ill. He needed an operation - and as the only doctor on the team, he realised he would have to do it himself. Tasking two assistants; one to pass him the necessary medical instruments and one a mirror to view his own abdomen. *"The bleeding is quite heavy, but I take my time... Opening*

the peritoneum, I injured the blind gut and had to sew it up," Rogozov wrote. *"I grow weaker and weaker; my head starts to spin. Every four to five minutes, I rest for 20 - 25 seconds."* After two hours of self-surgery, he succeeded in closing himself up, having successfully removed his appendix³.

The ability to make decisions in isolation, drawing upon a broad swath of medical knowledge, makes extreme medicine so unique. And it relates to the modern world. Extreme medics were among the first to respond to the 2013 Ebola outbreak of COVID-19 but are also at the forefront of our exploration of Space, as NASA Astronaut Mike Barratt highlights: *"It's analogous to exploration expeditions of old - there are lots of things we won't be able to carry to Mars, and the highest levels of medical care will be hundreds of millions of miles away,"* says Barratt. *"The individual, the crew, the space agency and the public will have to accept that degree of risk."*⁴

Mental robustness is part of the mix, but that benefit flows both ways. One thing that has become very apparent to me in my almost thirty-year exposure to expedition, and now extreme, medicine is that medical professionals often experience a reconnection to the medicine they imagined at the beginning of their careers. Anecdotally, we know medics return to their mainstream medical careers as more proactive problem-solvers who work more effectively in teams but with well-developed leadership skills. There is a circular growth that benefits medical professionals on a personal level, professionally, and society as a whole.

CONFIDENCE AND COURAGE

Very few mid-winter rescues have ever been conducted in Antarctica, and they are ranked as some of the most logistically complicated missions. Perpetual darkness, extreme temperatures, complicated aircraft landings, and unpredictable weather are just some considerations.

In late April 2015, Dr Tim Nutbeam, an NHS Emergency Medicine Consultant and medical lead for Devon Air Ambulance, was smuggled onto a plane carrying a big bag of blood to attempt a rescue mission in Antarctica. His mission was to assist critically ill British Antarctic Survey engineer Malcolm Roberts, based at Halley Research Station on the Brunt Ice Shelf. The team landed in Halley after 24 hours

of travel. Getting to the casualty required a snowmobile trip to the station itself, where he successfully performed what is thought to be the first Antarctic blood transfusion on Roberts. Meanwhile, the engineer kept the plane's engines warm to ensure they didn't freeze in the -30°C (without windchill) temperatures.

Tim wasn't even supposed to be on the continent; he was the backup medic, but flight delays and an unusually clear weather window put him in the seat. When asked to comment on the reasons for the successful operation, his answer was *"excessive planning was less important than having confidence in one's own skills"*.

This confidence in medical skills tipped the balance in the Thai Cave Rescue for Australian anaesthesiologist Richard 'Harry' Harris. His justification for attempting such a daring rescue was that he truly believed it would work. It was a calculated risk based on years of both medical and caving experience, utilising a predominately medically inexperienced rescue team. *"It's all in that moment, it's all about falling back on your training, and also having that mindset of 'I have to keep things under control'. You have to avoid panic. As soon as you start to panic you lose that ability to solve problems and move forward"*⁵.

Psychology researcher Nathan Smith, based at the University of Manchester, believes people who take part in extreme expeditions often are motivated by the chance to do something that not many people do and that certain personality types fare better in extremes. Research has shown that people who are less neurotic perform better. *"What we see is that people in high-risk jobs are not easily anxious, and when they are, they are able to control it quite well"*⁶.

Some recent research suggests that the so-called 'Explorers Gene', present in 20% of the population, might have some part to play. Research on the gene *DRD4-7R*, often referred to as the dopamine receptor *D4* gene, has been linked to a number of personality traits but points to a higher tolerance to dopamine requiring a higher stimulus level for it to be triggered, increasing the chances of risk-taking or, possibly, the desire to explore.

The connection to different skills gives clinical mobility and courage. This is especially evident in the training of remote



Photo 1: Pre-hospital assessment and management is logistically challenging.

doctors in Australia, highlighted by the work of the Australia College of Remote and Rural Medicine (ACCRM). This celebrates a generalist, well-rounded educational approach, providing clinicians with a broad base of knowledge to draw upon much needed due to the remoteness of their work. However, this needs to be tempered by 'clinical courage', which was particularly highlighted during the COVID-19 pandemic. Rural doctors typically work in low-resource settings and with limited professional

support. They are sometimes pushed to the limits of their usual scope of practice to provide the medical care needed by their community⁷.

With the WEM Faculty as a source, I requested a short list of their more unusual clinical cases;

- Injured climber stuck on high altitude high angle ledge with search and rescue team overnight in an unexpected blizzard.
- Man with angioedema on small

Caribbean Island I just happened to be travelling with my expedition pack because I came from Alaska.

- Multiple eagle attacks with shredded scalps out in the Aleutian Islands.
- Surfer with deep to the bone impalement injury to upper thigh 3 hours from a hospital from surfboard fins stabilised in small island clinic.
- Medevac plane crashed into the Bering Sea they extricated into a lifeboat with injuries. They were picked up by a nearby island harbourmaster in a boat.
- A Man in the U.K. attended my E.D. with urine retention and felt 'wriggling'. Backstory, he'd been installing generators in the Amazon 2 weeks prior. Villagers washed their clothes in the river. Candiru small fish swam up the wrong stream!
- Tyson Bottenus brain mould.
- The extreme survival of Anna Bågenholm.

EDUCATIONAL AND TRAINING - PREPARING FOR THE UNKNOWN

The possibilities are endless, and to operate confidently and with sufficient mental

bandwidth in extremis, one needs specific training such as mountain, Space, or humanitarian training. However, there are the cornerstones that underpin all of them.

Whilst you might be the only medic for hundreds of miles unless you are acting as a rural general practitioner, you are likely to be part of a larger team, an expedition, a humanitarian deployment or a tactical group. A clear understanding of human factors and developing interpersonal communication skills are fundamental. Know your medicine, do the basics well, and remember your scope of practice. Brushing up on your Advanced Trauma Life Support (ATLS) skills will undoubtedly give you additional confidence.

Attending a foundational extreme or expedition medicine course provides a great introduction to the diverse types of medical knowledge you need to onboard and an excellent opportunity to network and learn from peers. Of course, the annual November WEM Conference is the gathering point for many people working in this area.

If you have access to communications, Starlink provides excellent bandwidth, utilising established and emerging

telemedicine platforms that can serve as a skills amplifier, provide you with clinical governance, and an invaluable reach-back facility. NASA use Doxyme, for instance.

HUMAN FACTORS IN EXTREMES

Lack of sleep, fatigue, and overwork sound very much like the clinician's normal workload but add to these changing diets, isolation, increased cultural considerations, poor road transport, being far from home, cold, frozen, heat exhausted and increased environmental risk, with the possibility of being taken hostage or being sucked out into the vacuum of Space. All these add to the piquancy of an extreme medicine life. To re-emphasise, 'Extreme Medicine is not for the faint-hearted'.

Deployments can come at a cost. Trauma Risk Management ('TRiM'), is a valuable tool worth exploring⁸. TRiM is a peer support system developed within the British Armed Forces to ensure that trauma-exposed personnel are appropriately supported and encouraged to seek timely help should they develop mental health problems that fail to resolve spontaneously.



Photo 2: Teamwork is vital in challenging conditions.



Photo 3: Expedition medics need to learn to not just survive, but to thrive in diverse environments.

Refreshing your knowledge of post-traumatic stress disorder (PTSD) should also be part of your pre-deployment workup when responding to humanitarian, disaster or tactical medicine emergencies. Symptoms include, but are not limited to: 1) recurrent, unwanted, distressing memories of the traumatic event, 2) reliving the traumatic event as if it were happening again (flashbacks), 3) upsetting dreams or nightmares about the traumatic event, 4) severe emotional distress or physical reactions to something that reminds you of the traumatic event.

Human Factors is a key module in the University of Exeter's MSc in Extreme Medicine, for a good reason. Andy Hughes, a former special forces medics, describes how this translates into real life: *"As a paramedic, I wasn't just fixed with a trauma and medical emergency role on a regular basis, I would find myself delivering primary health care, environmental health, involved in plenty of medical planning. There was never a dull moment. One week I would be at a UK base working in the medical centre. The following week, deep in the heart of the jungle with a med kit in my backpack, days from definitive medical care. A military career has also equipped me with some useful soft skills such as mental and physical resilience,*

adaptability and a deep understanding of leadership and management which have all come in handy since leaving. However, it was not all sunshine. There were tough days too. I lost more friends than I have fingers. I missed a lot of my kid's birthdays. But if I had the chance to start over as that 17-year-old eager boy to see the world and find my purpose, I'd do it all again."

FUTURE TECH AND ARTIFICIAL INTELLIGENCE (AI)

Healthcare in general is undergoing a revolution. We are witnessing the advent of sophisticated telemedicine solutions and the shrinking of portable equipment. What would have seemed like science fiction a decade ago is now commonplace, and this is changing diagnostic possibilities in extreme environments. Weight, portability, expense and battery strength remain limiting factors, especially in cold environments, but AI is issuing in another revolution. AI has the potential to improve diagnostic accuracy through image analysis, enabling real-time health monitoring, optimising resource allocation, and facilitating telemedicine consultations. This will ensure better patient outcomes, improve healthcare accessibility, and increase the number of patients who can be treated.

Of course, reducing clinical error is critical. However, when resources are poor and other factors add stress and reduce bandwidth, AI-based tools that can increase diagnostic accuracy will help support the mental health of medics working in extremes.

EXTREME MEDICINE, A CHANGING WORLD AND THE FUTURE

Distinctly different from traditional medicine, founded on adaptability and resilience, the discipline of extreme medicine plays a significant role in enhancing our disaster response and preparedness, particularly to natural disasters. As climate change allows diseases such as Dengue to spread, it is becoming crucially important to strengthen our global health security by having the clinical capacity to respond to increased risk of epidemics and pandemics.

Deborah Swann, a nurse based in the U.K. who works as an advanced clinical practitioner in emergency medicine, describes her role in the UKISAR team: *"I work as an advanced clinical practitioner in emergency medicine. I'm also the only nurse on the UK International Search and Rescue Team, which is a UK government organisation that responds to natural disasters worldwide. In 2023, I responded with*

“Extreme Medicine is not just a profession—it’s a calling. It exposes medics to areas of medicine beyond the confines of traditional clinics, fostering innovation, courage, and adaptability.”

the team to the devastating earthquakes in Turkey and in Morocco, and part of my role within that team was to go into collapsed structures and initiate medical treatment for trapped casualties whilst they were being rescued. What I like about this work is the fact that it is risky, it’s dangerous, it’s thrilling, it’s exciting, it’s terrifying, it is harrowing. It’s also rewarding. Being part of the team is a privilege. I also feel a sense of satisfaction that I have broken into predominantly male environs, and there aren’t many nurses that I know who do this job. How have I done this? I’ve got here through hard work, determination and not taking ‘no’ for an answer.”

Human exploration of Space and the medicine that supports it draws on the legacy of our forebearers but also illuminates the future. The Chief Medical Officer of NASA, Dr James D Polk, describes the interaction between extreme medicine and Space Medicine: “Extreme Medicine is not just a profession—it’s a calling. It exposes medics to areas of medicine beyond the confines of traditional clinics, fostering innovation, courage, and adaptability. As we work on making astronauts self-sufficient and adaptable to any crisis that may occur on another planet, we have continued to interact with our extreme medicine practitioners. The light, lean, efficient equipment as well as the training and mindset, serves as a benchmark for us to compare the training that we may give

exploration astronauts. Adaptability in constrained environments is key to extreme medicine, and it may just be a skill needed by intrepid healthcare providers on exploration missions to other planets, to safeguard humanity’s future, one life at a time”.

CONCLUSION

Extreme medicine is an exciting part of medicine, allowing medics to practice their science and art, whilst also satisfying their need for exploration and adventure. It is a growing speciality, built on hundreds of years of history, now becoming increasingly evidence-based and integrated with other areas of medicine - including sports medicine. It is not for the faint-hearted, and a certain degree of courage, and perhaps genetic pre-disposition, is required. However, appropriate training in not only medical skills, but also psychological resilience and human factors, increases the confidence and enjoyment of medics working in low-resource and austere environments. The contributions of extreme medicine practitioners to global health are becoming increasingly important, with climate change increasing the risks of natural disasters and pandemics. However, perhaps some of the most exciting future prospects for extreme medics is the opportunity to contribute to the knowledge and resilience required when humans explore the final frontier: deep space and other planets.

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