



Commentary

Medicine in the deep: delivering care in the submarine battlespace

Craig Thorniley-Moore¹, Timothy Makrides^{*2}

¹Submarine Medic, Royal Australian Navy

²School of Health, Medical & Applied Science, Central Queensland University, Rockhampton, Australia

*Corresponding author email t.makrides@cqu.edu.au

Abstract

Submarine operations occur in one of the most austere medical environments in modern military practice. Once submerged, clinicians must provide care in a confined, isolated setting with limited diagnostic capability, finite medical supplies, and unpredictable timelines for evacuation or specialist consultation. A single medic is typically responsible for the health needs of more than fifty crew members while operating under conditions of fatigue, communication restrictions and significant operational constraints.

This editorial highlights the clinical, operational and psychological challenges associated with healthcare delivery in the submarine environment. Common presentations, such as chest pain, appendicitis, trauma and dental emergencies, carry heightened risk when definitive care may be days away. In addition, prolonged isolation, disrupted circadian rhythms and confined living conditions create ongoing mental health pressures for crew members.

Despite these complexities, submarine medicine remains poorly understood outside the submarine community. Increasing awareness of this uniquely austere clinical setting is important for ensuring that training, capability development and policy frameworks reflect the realities of healthcare delivery beneath the sea.

Keywords submarine medicine, austere clinical care, navy, operational medicine, medicine.

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Introduction

Submarines operate in one of the most restrictive medical environments on Earth.¹ Few outside the submarine community understand and appreciate how complex and resource-limited medical care becomes once a vessel submerges.

This short editorial aims to raise awareness of the complexities around austere medicine in the submarine environment to broaden understanding and allow for better preparation and policy settings.

Operational context

Consider an environment where two adults cannot stand shoulder-to-shoulder in most passageways, where headroom is limited for taller personnel, and where movement must be carefully controlled to avoid disturbing sleeping crew. Off-watch rest periods are short, fragmented, and routinely limited to approximately 5.5 hours at best, creating a persistent baseline of fatigue throughout the submarine.

Submarines are designed for extended, independent operations at sea, frequently at significant distance from shore-based medical and logistical support. Their mission profiles prioritise

stealth, security and operational endurance, resulting in prolonged periods of isolation within a closed environment. Because mission routes, operation patterns, and future timelines are withheld from most personnel on board, clinical staff at times have no visibility of when the submarine may next surface, rendezvous or come within range of external assistance. As a result, opportunities for medical evacuation or specialist consultation cannot be predicted, and all healthcare planning must proceed under the assumption that definitive care may be delayed indefinitely, with onboard resources representing the primary and potentially only treatment capability for the duration of the mission.

When operating submerged, routine communication with external medical support is not available, and clinical personnel are unable to seek real-time consultation from a Medical Officer. When communication is available, it is typically limited, delayed and maybe degraded to the point that clinical details cannot be clearly exchanged or verified. Consequently, time-critical interventions must be initiated based on the practitioner's training, clinical judgement and the limited reference material available on board, such as the Primary Clinical Care Manual. Pharmacological management is restricted to the medications

carried, and only conditions represented within authorised guidance can be treated with formal evidence-based protocols. In addition, any medical decision with operational, personnel, or safety implications, including removal from duty, medication initiation, procedural intervention or planning for potential evacuation, must be discussed with the Commanding Officer, who is ultimately responsible for command decisions but does not possess medical qualifications. This communication isolation remains a core factor underlying the cognitive practice within an austere environment.

Medical capability and limitations

On an Australian submarine, a single clinician is responsible for the healthcare needs of more than 48 crew members. Newly qualified submarine medics typically enter the role with a Diploma of Nursing (Enrolled/Division 2) and limited exposure to the unique demands of the submarine environment. Their initial deployments therefore require rapid adaptation to an austere, resource-limited clinical setting while managing routine and acute presentations. Senior medics, designated as Clinical Managers, complete additional tertiary training and hold a Bachelor in Paramedical Science, but they too practise without immediate specialist support while at sea. Regardless of experience level, the medic functions as the primary point of care for all injuries and illnesses on board, and is expected to provide sound clinical judgement across a broad range of presentations including systemic illness, mental health concerns, and potential cardiovascular events, often while being several days away from accessing external medical advice or definitive care.

Clinical and psychological challenges

Submarines present a uniquely austere clinical environment where otherwise common presentations, such as chest pain, carry significantly elevated risk.² These conditions pose not only immediate concerns for the patient but also potential operational and strategic implications for the vessel. Diagnostic capability is limited; for example, there is no point-of-care testing such as an i-STAT device to confirm troponin levels, and ECG interpretation is often complicated by motion artefact, particularly in unfavourable sea states.

Other acute conditions also become more challenging to manage in this setting. Appendicitis remains a high-risk presentation due to the lack of imaging, surgical capability and reliable evacuation timelines. Dental emergencies, although uncommon because crew are screened and treated pre-deployment, can still occur and rapidly become debilitating when analgesia, antibiotics, and definitive treatment options are restricted. Head injuries are also frequent hazards in the confined space, with lacerations and minor trauma common, as personnel inadvertently strike overhead structures or bulkheads. Even seemingly minor head wounds can have disproportionate consequences when space, lighting, equipment and follow-up capability are limited.

Although significant trauma is unlikely within the submarine environment,³ the capacity to manage it is severely restricted. Haemorrhage control options are limited, with only small quantities of haemostatic agents available and no access to blood products or tranexamic acid. Recent reductions in carried equipment, including the removal of dedicated burns boxes and dressings, mean that burn management is largely confined to cooling with showers or laundry sinks, analgesia, antibiotics, fluids and improvised coverings, such as plastic wrap.

Fluid resuscitation capacity remains a critical limitation. Submarines carry a finite volume of intravenous fluids, sufficient for the initial management of only a limited number of casualties. For adult patients, standard resuscitation requirements can rapidly deplete available supplies over a 24-hour period. This constraint becomes especially problematic when evacuation may be delayed for more than 24 hours due to operational or environmental factors.

Pain management is similarly resource-limited. Although medics have access to agents such as morphine, fentanyl and ketamine, these supplies are finite. In a multi-casualty situation, sustaining appropriate analgesia over time would rapidly deplete available stock. These constraints highlight the inherent vulnerability of trauma and burns care on submarines, where every clinical decision must account for resource scarcity and unpredictable timelines to definitive treatment.

Mental health risk on submarines is driven by three core factors: isolation, circadian rhythm disruption and a confined social environment.⁴

During deployments, communication with families is effectively absent. Crew receive only brief 100-character family grams, which provide minimal emotional connection or support. Prolonged isolation from external social networks is associated with increased stress, reduced coping capacity and cumulative psychological strain.

Circadian rhythm disruption is constant. Seasonal variation significantly affects light cycles, and the submarine watch routine makes normal sleep regulation almost impossible. Sleep debt accumulates quickly and directly impacts mood stability, cognitive performance and overall mental resilience.

The confined social ecosystem amplifies these stressors. Living and working in the same restricted space with the same individuals for extended periods limits opportunities for decompression and healthy boundary-setting. Interpersonal tension escalates more quickly and minor stressors carry greater psychological weight. Over time, this environment increases vulnerability to low mood, irritability, anxiety and other emerging mental health concerns.

Provider expectations and skill profile

Submarine medical care is delivered by a single clinician within an environment defined by isolation, limited resources and restricted access to external support. The role extends beyond routine primary care and requires competence in emergency management, prolonged casualty care, mental health assessment and preventative health.

Clinical decision-making is frequently undertaken without access to definitive diagnostic tools or continuous specialist consultation. Although limited communication with the Fleet Medical Officer may be possible via satellite phone, such contact is often intermittent, degraded or unavailable for prolonged periods due to operational requirements. As a result, clinical management relies heavily on the practitioner's foundational knowledge, clinical judgement and risk-based decision-making.

Medical recommendations may carry operational consequences and must be communicated effectively to the Commanding Officer, who retains decision-making authority despite not having medical training. This necessitates clear articulation of clinical risk, uncertainty and potential outcomes to support informed command decisions.

Collectively, these demands require a high degree of clinical autonomy, adaptability and professional resilience. Submarine medicine, therefore, constitutes a distinct clinical practice environment, requiring preparation that extends beyond conventional training models and into sustained independent practice under austere conditions.

Why awareness matters

Despite its complexity, submarine medicine remains poorly understood outside the submarine community. Limited awareness among clinicians, policymakers, and the broader public risks underestimating the clinical demands placed on submarine medical personnel and the constraints under which care is delivered. One contributing factor is the application of a largely uniform naval medical skill set across diverse operational platforms, despite submarines presenting markedly different clinical, environmental, and evacuation constraints.

This standardisation may obscure the extent to which submarine medical practice requires a broader scope of autonomous decision-making, prolonged care capability and risk tolerance than is typically expected in other maritime settings. Without recognising these distinctions, training, credentialing and capability development may fail to fully reflect the realities of submarine healthcare delivery.

For clinicians, improved awareness supports more accurate expectations regarding clinical autonomy and responsibility in isolated environments. For non-clinical stakeholders, including policymakers, and the general public, understanding these

differences provides essential context for how health risk is managed in a setting where evacuation and specialist support cannot be assumed.

As submarine operations continue to evolve in complexity and duration, informed discussion around platform-specific medical capability becomes increasingly important. Awareness is a foundational step toward ensuring that submarine medical systems are appropriately aligned with operational realities, while maintaining safety, effectiveness and professional accountability.

Future directions and educational needs

The unique constraints of submarine operations highlight the importance of education and preparation that is specific to the submarine medical environment. While core naval medical training provides a common clinical foundation, additional submarine-specific exposure is essential to prepare clinicians for the level of autonomy and responsibility required at sea.

Structured pre-deployment exposure to submarine operations, including supervised time on board and scenario-based training, may assist in bridging the gap between formal qualification and independent practice. Emphasis on decision-making under uncertainty, prolonged casualty care and management of low-frequency, high-impact events would better reflect the realities of submarine medicine.

Equally important is deliberate training in communication and shared decision-making with Commanding Officers and senior medical staff. New or less experienced medics cannot be expected to immediately navigate complex clinical and operational decisions in isolation. Education that focuses on articulating clinical risk, managing uncertainty and engaging effectively with command and senior medical oversight may improve both clinical confidence and patient safety.

Ongoing engagement with senior medical officers, combined with realistic simulation and mentoring, offers a pathway to develop clinical judgement within the constraints of the submarine environment. As awareness of these requirements increases, educational frameworks can continue to evolve to support safe, effective and sustainable submarine medical practice.

Conclusion

Submarine medicine represents a distinct and highly challenging clinical environment, defined by isolation, constrained resources and operational complexity. Clinical personnel are required to function autonomously across a broad spectrum of presentations, from routine primary care to acute medical, psychological and trauma scenarios, often without immediate access to specialist support or evacuation. The unique combination of physical constraints, limited diagnostic capability and restricted communication with command and external medical advisors

underscores the cognitive and professional demands placed on submarine medics.

Awareness of these challenges remains limited outside the submarine community, including among clinicians, policymakers, and the general public. Improved understanding of the operational and clinical realities of submarine medicine is critical for developing targeted training, appropriate resource allocation and realistic expectations of medical capability at sea.

As submarine deployments continue to increase in complexity and duration, education, simulation and structured exposure tailored to the submarine environment are essential. Recognising the distinct requirements of submarine medical practice ensures that clinical care remains safe, effective and aligned with the operational realities of one of the most austere and demanding healthcare environments in existence.

Conflict of interest

The authors declare no conflicts of interest.

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