Cyber & Specialist
Operations Command

Defence Medical Research Strategy 2026-31

Foreword

The world is increasingly unstable. For the first time since the end of the second world war there is large-scale conflict in mainland Europe. State and non-state actors continue to pose a threat to the UK and its allies with a proliferation of sub-threshold activity. Climate change, anti-microbial resistance, novel weapons, and the erosion of humanitarian law magnify the challenges that we face. As well as providing huge opportunity, AI and synthetic biology put sophisticated threat capability in the hands of groups willing to use them against us.

As laid out in the Government's Strategic Defence Review, the UK must deter and prevent war by being ready to fight. If deterrence fails, we must be prepared to enter peer-on-peer conflict.

It is against this backdrop that the Defence Medical Command (DMedC) publishes its Research Strategy. The DMedC is at the forefront of medical operational capability. Continuous, targeted research and development efforts help us remain at the leading edge. To tackle the challenges with which we are faced, and continue to preserve the moral component of warfighting, we must conduct research activity that ensures the fitness of the fighting force and positions us to save the lives of personnel injured in combat.

The themes presented in this strategy – framed within the context of large-scale combat operations – directly address the most pressing priorities of Defence Medical from firm base to kinetic operations. UK Armed Forces personnel must be **fit to operate** and their **mental health** must be protected. We must be ready to operate at **environmental extremes** and manage a high burden of evolving **infection**. We must innovate to **save lives on a contested battlefield** whilst remaining a step ahead of **complex and emerging threats.**

Delivering this breadth of activity requires the mobilisation of the Defence and national research ecosystem. Defence Medical cannot act in isolation and must leverage existing infrastructure, establish and maintain academic and industry collaborations, and tap into wider funding resources. We must continue to partner with international allies in order to share data and best practice, de-risk large-scale investment, and ensure the interoperability of the outputs that emerge from R&D efforts.

The pipeline integration of research, implementation and innovation partners across DMedC and wider Defence remains key to enable the rapid uptake of research into core capability and Defence medical policy. Opportunities presented by the establishment of UK Defence Innovation should be fully exploited, as well as ensuring strong advocacy for the importance of medical research within the wider structures of the National Armaments Director Group.

Foreword

I commend this insightful, targeted research strategy that provides the demand signal for military medical research across the DMedC, wider Defence, and the civilian sector. The strategy sets out a realistic framework on which to base our military medical capability development and prepare ourselves for the future fight.

Chief of Defence Medical

Air Marshal Clare Walton
CB CStJ KHP

Contents

Linkages

This Strategy is informed by and coherent with a number of policy, strategy and conceptual publications. These include:

- **Strategic Defence Review 2025**
- **NATO Medical Action Plan**
- **Future Medical Operating Concept 2025**
- **Defence Medical Functional Strategy**
- **RCI Clinical Implementation Strategy v5**
- **Submarine Health Research Strategy**
- **Defence Medical Chemical, Biological, Radiological and Nuclear Research Prioritisation**
- **UK Biological Security Strategy**

Introduction

Purpose

The purpose of the Defence Medical Research Strategy 2026-31 ('the Strategy') is to form the demand signal for UK military medical research conducted within the Defence Medical Command (DMedC), the wider Ministry of Defence (MOD), and the civilian academic and industrial sectors.

It is the capstone research strategy outlining the key themes that will guide research activity and funding decisions. Subordinate strategies might exist within the Academic Departments of DMedC Research and Clinical Innovation (RCI) or for cross-cutting areas (e.g. Public Health, Chemical, Biological, Radiological, and Nuclear (CBRN) medicine) but these will align to the direction of this document.

Context

The UK Strategic Defence Review 2025[1] (SDR) articulates the context within which this Strategy is framed. The geopolitical climate is volatile and uncertain. The UK Armed Forces (UKAF) must be positioned to deter and prevent full-scale war by being ready to fight and win. If deterrence fails, the UKAF must be prepared for peer-on-peer conflict. These large-scale combat operations (LSCO) will be prolonged, contested, and multi-domain.

Medical support is vital for the moral component of fighting power. Few would be willing to start or continue a service career, let alone fight, without clear evidence that they will be provided with the best possible healthcare and emergency support.

The Defence Medical system[a] must be primed to support the demands of LSCO, from ensuring as many service personnel (SP) as possible are fit to operate through to management of mass casualty events. The conduct of rigorous, leading-edge research and development – coupled with robust implementation and innovation – is critical in enabling Defence Medical (DMed) to remain at the forefront of military medical capability in all operational contexts, thereby preserving the moral component.

Interpretation

The priorities specified within this Strategy are based on consultation across the Commands[b]. They reflect the most pressing areas of need that DMed is best placed to tackle (i.e. those that fall under the responsibility of the Medical Function to address) and that require investigation through research. This excludes issues that fall primarily in the Personnel, Infrastructure, Finance, and Policy areas.

a The Defence Medical system refers to broad elements of national medical capability able to support Defence medicine and health (including the National Health Service).
b Stakeholders were invited to contribute to a consultation exercise to inform future research priorities. The invitation directed participants to a survey where they could submit up to 12 research priorities. Individual DMedC RCI Academic Departments and cadres also conducted internal consultations and submitted consolidated priorities for inclusion. A total of 115 submissions were received to the survey, containing 482 research priorities. Two reviewers independently screened all submissions for scope and remit. A total of 165 entries were excluded. The remaining 317 in scope research questions were consolidated into 46 research topics and subsequently grouped into six overarching themes.

Although various overlaps are acknowledged throughout the Strategy, primary responsibility for driving change in these areas fall outside DMed. Similarly, priorities that are best addressed through audit, quality improvement, service evaluation, or better implementation of known capability are outside the scope of this Strategy.

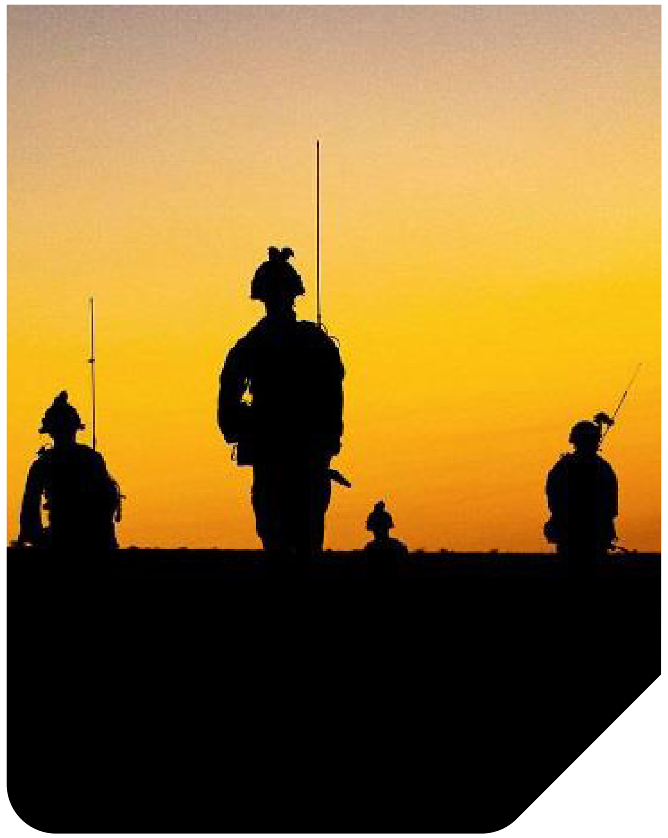
Priorities are specified at two levels: overarching research themes and component research topics. Themes and the topics within them are non-hierarchical; none is more important than the other and all will grow the Defence medical knowledge base.

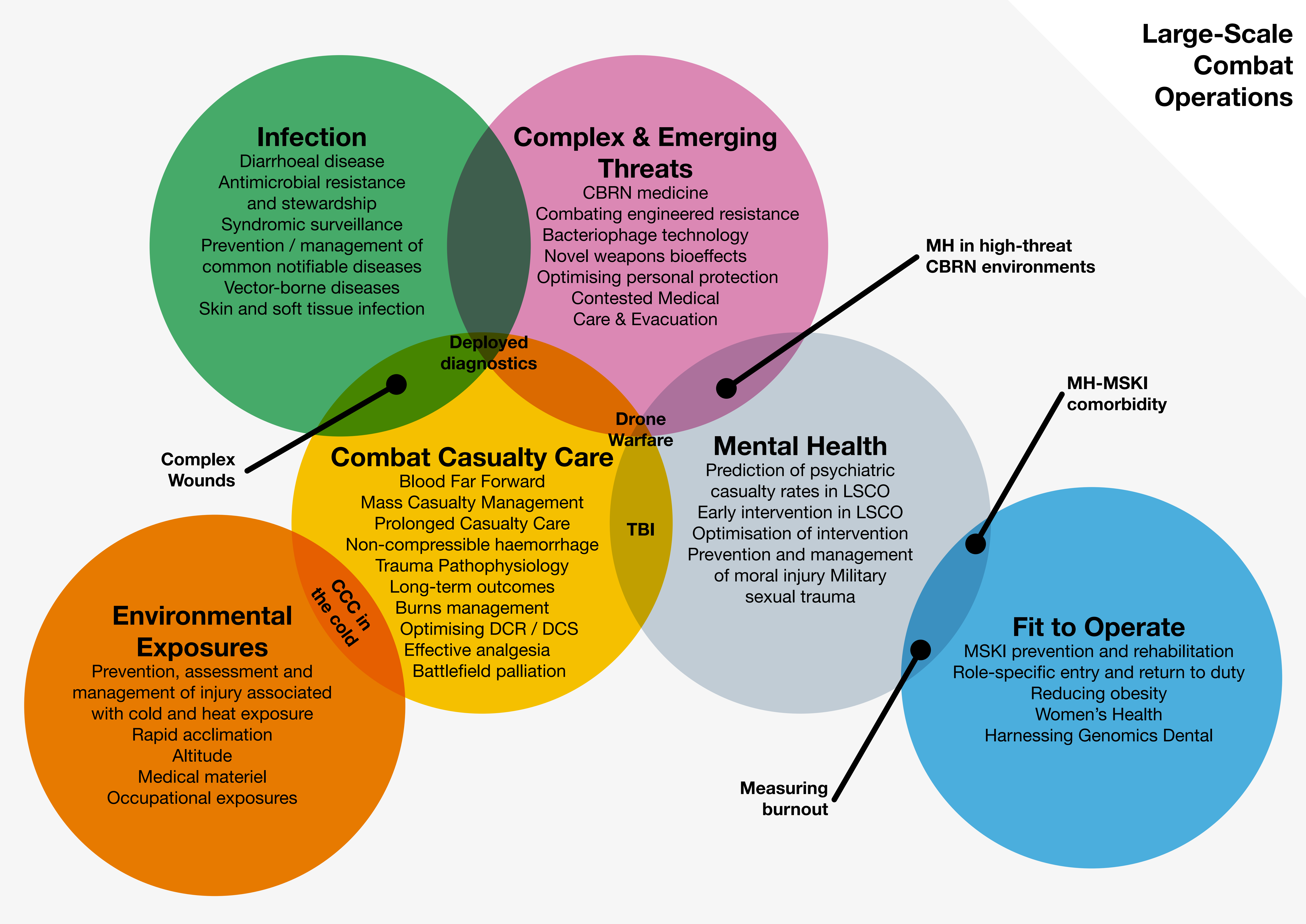
LSCO is not specified as a theme in itself, but provides the wider context in which all of the themes are framed. Sometimes this is explicit, for example, in the management of mass casualty events. At other times this is implicit, for example, protocols enabling rapid acclimation to heat must be rapidly scalable rather than overly bespoke. Every research topic should be considered against the background of preparation for, and engagement in, large-scale conflict. Doing this will focus the research question on the most pressing concern.

Some topics overlap two or more themes; for example, the topic of complex wounds crosses the boundaries of Combat Casualty Care and Infection. These topics, requiring significant inter-disciplinary and cross-specialty collaboration, are discussed in boxes throughout the document.

Some of the priorities will already be subject to ongoing activity. They are still named in the Strategy to signal their importance both internally and externally. They are often multi-faceted problems that are rarely solved by isolated activities or single research studies, instead requiring long-term engagement and investment.

This Strategy focuses on research and development as per the definition under Joint Service Publication 536: the attempt to derive generalisable or transferable new knowledge to answer or refine relevant questions with scientifically sound methods. Clinical Innovation and Implementation are separate but related activities with their own strategies. As per the remit of the DMedC, this Strategy addresses research priorities of relevance to the serving population.




Large-Scale Combat Operations
Infection
Diarrhoeal disease
Antimicrobial resistance and stewardship
Syndromic surveillance
Prevention / management of common notifiable diseases
Vector-borne diseases
Skin and soft tissue infection
Complex & Emerging Threats
CBRN medicine
Combating engineered resistance
Bacteriophage technology
Novel weapons bioeffects
Optimising personal protection
Contested Medical Care & Evacuation
MH in high-threat CBRN environments
Deployed diagnostics
Complex Wounds
Drone Warfare
Combat Casualty Care
Blood Far Forward
Mass Casualty Management
Prolonged Casualty Care
Non-compressible haemorrhage
Trauma Pathophysiology
Long-term outcomes
Burns management
Optimising DCR / DCS
Effective analgesia
Battlefield palliation
TBI
Mental Health
Prediction of psychiatric casualty rates in LSCO
Early intervention in LSCO
Optimisation of intervention
Prevention and management of moral injury Military sexual trauma
MH-MSKI comorbidity
CCC in the cold
Environmental Exposures
Prevention, assessment and management of injury associated with cold and heat exposure
Rapid acclimation
Altitude
Medical materiel
Occupational exposures
Fit to Operate
MSKI prevention and rehabilitation
Role-specific entry and return to duty
Reducing obesity
Women's Health
Harnessing Genomics Dental
Measuring burnout

Fit to Operate

- **Musculoskeletal injury (MSKI) prevention and rehabilitation, including novel intervention**
- **Role-specific entry and return to duty**
- **Reducing obesity**
- **Women's health**
- **Harnessing genomics for through-career health**
- **Dental morbidity**

Central to the DMed component of the SDR was the drive to maximise deployability of SP to meet operational requirements. This was captured under Recommendation 58:

"Create … measures to return non-deployable personnel to fighting fitness as quickly as possible…"

MSKI is currently the leading cause for medical downgrading and a persistent cause of medical discharges. As of 2024, internal Defence data showed almost half of SP who were medically downgraded were due to MSKI, which equates to over 1 in 10 of the Regular UKAF population. MSKI is also one of the greatest constraints on throughput from initial military training, contributing to difficulties in UKAF meeting recruitment targets. MSKI is therefore a crucial medical factor that has a profound long-term impact on Force Generation and Operational Effectiveness[2]. If UKAF are to be Fit to Operate, **preventing and treating MSKI is fundamental.**

Mitigating MSKI risk in the UKAF population does not fall solely within the auspices of the DMedC and a holistic approach must be taken. Risks are multifactorial, including both modifiable (nutrition, body weight, nicotine and alcohol use, sleep) and non-modifiable (age, sex, previous injury) factors. Leadership, culture, and resource allocation are wider determinants that can have a direct and indirect impact on MSKI risk and should be considered when proposing novel prevention and intervention strategies. This understanding underpins the Royal Navy's whole system approach to MSKI mitigation from which lessons can be learned across UK Defence. Whilst we must strive to develop better prevention and rehabilitation strategies for MSKI they must take into account the wider ecosystem in which they are placed.

In a LSCO context, the exquisite care provided by Primary Care Rehabilitation Facilities (PCRFs), Regional Rehabilitation Units (RRUs), and the Defence Medical Rehabilitation Centre (DMRC) will likely be unsustainable. Research efforts must consider how we deliver **scalable, self-guided MSKI rehabilitation** programmes outside of traditional settings to return SP to full operational deployability as quickly as possible. Specifically, shortening the duration between medically limited deployability (MLD) and full deployability status is key, where the SP has returned to their primary unit and may be less able to engage with prescribed rehabilitation. This results in further delayed return to duty and increased risk of re-injury. It requires ownership to be placed in the hands of the service person via validated, high-quality self-guided platforms coupled with education and support from Command.

UK Defence must also continue to explore **novel, early interventions** for delivery in specialist rehabilitation settings that increase the chances of rapid return-to-duty. Pharmaceutical interventions for osteoarthritis (OA), for example, are typically developed to target advanced disease in older populations. Determining their efficacy in slowing disease progression – thereby allowing longer service – in physically active, younger individuals is a DMed priority, as is the investigation of pharmaceutical agents able to improve post-operative recovery speed.

We must also better understand where **return-to-duty thresholds** sit for different occupational groups moving away from a one-size-fits-all approach. This is in line with direction under the Future Medical Operating Concept 2025 (FMedOpC25) to base the medical fitness standard on more granular risk metrics. To meet this intent, efforts should be made to produce objective baseline performance measures specific to occupational groups against which SP can be compared when making return-to-duty decisions. This will – and should – differ depending on the tasks required of each group. As well as providing objective evidence for when to recommend return-to-duty, such metrics will also provide quantitative markers of progress during rehabilitation and promote adherence to recovery programmes[3].

Medical entry standards exist to ensure the UKAF maintain operational effectiveness and to safeguard the individual and the teams they work within and alongside. To enable commanders to maximise the available workforce at an acceptable level of risk, FMedOpC25 urges the modernisation of the medical entry standard and associated processes. Shifts in this direction can be seen in Army's Cyber Direct Entry Scheme. If this is broadened to include combat-facing roles there will inevitably be implications for the individual and wider medical function. Research should closely track these long-term implications for individuals allowed to join UKAF with a condition that was previously a barrier to entry.

As stated, **obesity** is one of the leading modifiable drivers of MSKI as well as being associated with liver, renal and cardiac dysfunction, type II diabetes, infertility, asthma, sleep apnoea and several cancers. An estimated 65% of adults over 40 in the UK are classified as overweight or obese[4], which has implications for UK Defence should the need arise to rapidly uplift recruitment from the general population. While lower rates are expected within existing UKAF personnel, the repercussions of being overweight are amplified in physically demanding roles[5]. As with MSKI more broadly, obesity cannot be treated solely as a medical problem with a medical solution. Lifestyle intervention and the promotion of healthy choices are key. Nevertheless, incretin mimetics (tirzepatide, marketed as Mounjaro®) have recently emerged as a highly effective treatment for obesity, with individuals reporting higher satiety, ability to exercise and improvements in general wellbeing[6]. The DMedC has recently established the Services Metabolic Programme to Improve Deployability and Health (STRIDE). This service facilitates administration of incretin mimetics to SP to avoid the risks associated with private sourcing and lack of disclosure. Research should leverage and inform the establishment of STRIDE to answer crucial questions for the UKAF population, including the effects of incretin mimetics on muscle strength and power (both whilst on the drug and after discontinuation), exercise capacity and cardiovascular effects, and the occupational impact of drug side effects. If any negative consequences of incretin mimetic use are identified, further research should determine physical training programmes able to mitigate them.

A 2026 review of the physical health needs of UK ex-service women[7] is instructive when it comes to pinpointing causes for concern – and opportunities to act – whilst still in service. Ex-servicewomen are more likely than male counterparts to develop OA, experience migraines and thyroid disorders, and are more likely than female civilians to experience a host of MSKI conditions, chronic obstructive pulmonary disease, ovarian and breast cancers, and challenges with gynaecological health, fertility, and menopause. The Ministry of Defence has an ambition to grow the number of female SP[8] meaning **women's health** will have an increasingly profound impact on the UKAF's overall Fitness to Operate.

Research priorities include the need to better understand the burden of women's reproductive health needs in the UKAF; holistic strategies to reduce MSKI in females during phase I and II training; menstrual health through career; a definitive study of how various forms of hormonal contraception impact on bone health and mood; pregnancy in service and post-childbirth return to duty. Efforts to reduce the stigma around women's health and improve service provider expertise in managing women's health presentations are required, particularly concerning sexual and reproductive health and abortion-related care. Finally, the intersecting experiences of serving ethnic minority women in relation to women's health should not be overlooked.

Whilst the past decade has seen improvements in the delivery of equitable care, the next decade promises a further step-change towards personalised medicine[c]. This approach uses individual genetic, lifestyle, and environmental data to tailor treatments, moving beyond one-size-fits-all care and aiming for better outcomes, fewer side effects, and efficient resource use. DMed should harness the power of **personalised medicine, particularly genomics, to optimise through-career health** for the benefit of the individual and the wider organisation.

c Personalised medicine, sometimes called precision medicine, refers to the application of emergent technologies to better manage patients' health and to target therapies to achieve the best outcomes in the management of a patient's disease or predisposition to disease.

One clear application of personalised medicine is to ensure a service person is given the right drug at the right dose, first time around. It is known that drugs with pharmacogene-driven response variations are commonly used in military medical settings. Examples include ibuprofen, codeine, paracetamol, flucloxacillin, ofloxacin, suxamethonium, and sevoflurane[9]. Depending on an individual's genetic make-up they might respond differently to each of these drugs. Importantly, tests exist that enable us to predict response types. Pharmacogene profiling of entrants to Phase I training could, therefore, reveal that a service person does not receive analgesic benefit from codeine. If they were to experience lower limb pain during training, they could then be administered an alternative painkiller that allows them to complete initial training. Whether existing pharmacogene panels meet UK Defence requirements, and how the DMedC goes about implementing precision prescribing are topics for further research.

Genomics can also be used to predict an individual's response to environmental stimuli, particularly when coupled with knowledge of prior exposures. This could yield valuable insight into a service person's suitability for a particular role based on likely occupational exposures and allow mitigation measures to be put in place. For example, the overall burden of cold injury could be reduced if Defence were able to identify an individual with genetic susceptibility to cold injury coupled with known prior exposure to extreme cold (see Environmental Exposures).

Military personnel are subject to an increased occupational risk of **dental trauma** when on deployment[10] and during training[11]. High levels of chronic dental disease are also seen in military recruits when compared to NHS comparators[12], with dental morbidity recorded as one of the top five non-battlefield injuries affecting military operational capability[13]. Recent reports suggest DMed must be prepared to encounter significant chronic, untreated dental disease in partner force personnel that has progressed for many years without routine care[14]. The inclusion of **dental morbidity** for the first time under the Defence Medical Research Strategy reflects its potential impact on the occupational health of the fighting force. We must better understand the epidemiology of preventable and non-preventable morbidity, clinical outcomes associated with current interventions, and how best to mitigate morbidity in non-force generated populations.

The thread running through this Strategy is medical support to LSCO. There is a risk that this focuses attention solely on research to support saving lives on the battlefield. Combat casualty care is a critical function of DMed – hence its inclusion here as a priority research theme – but the burden of disease and non-battle injury, and the impact it has on warfighting sustainment should not be overlooked. They are ultimately complementary in achieving the same goal – fighting and winning in large-scale conflict.

Fit to Operate

Box 1
Measuring Burnout

Military careers involve frequent and unpredictable periods of high-intensity activity, deployment to high-risk and austere environments, constrained personal agency in decision-making, and prolonged separation from family, friends, and established support networks.

The World Health Organization defines burnout as a syndrome arising from chronic, unmanaged organisational and occupational stressors. Whilst many of the demands outlined above are shared with other safety-critical professions there are also unique military drivers that must be account for. These include the organisational context of military service, characterised by operational tempo, hierarchical control, mobility, and dual professional-military identity. In turn, the manifestation, measurement, and mitigation of burnout may differ within the UKAF compared to other professions.

Prolonged exposure to such demands is associated not only with emotional exhaustion, depersonalisation or mental distancing and reduced professional efficacy, but also of poorer mental health outcomes, including increased risk of common mental disorders and suicidal ideation. For DMed personnel, these pressures are compounded by recognised healthcare workforce stressors including moral injury, further elevating vulnerability.

Current population-level surveillance tools such as DMS CHECK and Operational Mental Health Needs Evaluations (OMHNEs) provide valuable cross-sectional insight into wellbeing. However, UK Defence currently lacks a validated military-specific burnout measure capable of capturing organisational realities across roles and contexts. Existing instruments, including the Maslach Burnout Inventory and Burnout Assessment Tool, may lack sufficient specificity and sensitivity for this environment. Given established links between burnout, reduced retention, and workforce strain, systematic exploration and development of a Defence-specific assessment framework should be considered a research priority.

Combat Casualty Care

- **Blood Far Forward**
- **Mass casualty management**
- **Prolonged Casualty Care**
- **Non-compressible haemorrhage**
- **Trauma pathophysiology**
- **Long-term outcomes**
- **Burns management**
- **Optimising DCR / DCS**
- **Effective analgesia**
- **Battlefield palliation**

Haemorrhage is a characteristic feature of traumatic injury and is the leading cause of preventable prehospital death in civilian trauma[15] and on the battlefield[16]. Survival after a significant haemorrhagic event depends on two outcomes being achieved: i) cessation of bleeding, and ii) replacement of the fluid volume and function of the blood lost. In whole blood, plasma constitutes the fluid volume as well as containing key proteins related to clotting, osmoregulation and tissue homeostasis; platelets are central to effective clotting, and red blood cells carry and off-load oxygen. These blood components are crucial life-saving assets..

The NHS is currently facing a critical blood shortage. More than 200,000 additional blood donors are needed annually to avoid a "red alert" threat to public safety[17]. UK Defence relies almost entirely on the NHS to supply its blood components; there is no separate donor pool or ring-fenced stock. If UKAF become engaged in LSCO the current critical shortage would dramatically worsen to the detriment of both military and civilian users. 100 severely injured casualties could potentially require 1,000 units of blood which represents 25% of the total donated in the UK per day[18]. Supply reliance on NATO allies will be unachievable in the event of a LSCO and therefore sovereign capability needs to be an essential element of wider R&D efforts to improve blood product supply.

In previous conflicts, conditions were favourable to enable **blood far forward** (i.e., provision close to the point of injury): frequent re-supply was possible through air superiority, the geographical area was small, casualty numbers were generally low, and large clinical teams in state-of-the-art medical treatment facilities (MTFs) were supported by biomedical scientists for blood management. The absence of these conditions in future peer-on-peer conflict drives the requirement for novel blood products with less supply chain fragility (i.e. less reliant on human donation), that can be stored for longer in ambient, hot and cold temperatures, and that can be universally administered regardless of blood group. Looking further into the future, products with longer lasting and more diverse therapeutic effects would provide added benefit (e.g. blood able to also deliver drug therapies to tissues in need). Hand-in-hand with better blood products is a requirement for better enabling technology, for example point-of-care tests that can provide confirmatory blood grouping and virus screening for emergency donor panels.

Mass casualty (MASCAL) management is one of the five main themes of the NATO Medical Action Plan (MAP). A MASCAL event refers to a situation where patient numbers overwhelm available medical capabilities, requiring rapid, coordinated, and often extraordinary measures. The 8Ds of MASCAL response[d] proposed by the UK DMed and NATO Emergency Medicine Panel[19] raise questions that are ripe for research investigation. These include:

- 'Decompressing' a treatment facility by discharging patients or passing them on for treatment elsewhere requires novel methods for monitoring large numbers of patients whilst in transit between facilities.
- 'Delegation' to the lowest capable care provider is essential, in line with FMedOpC25 direction to ensure we develop battlefield solutions not restricted to use by specialist providers. Ensuring interventions are robust and easy to self- / buddy-administer is critical.
- 'Delivering faster and better' requires identification of interventions used in the military context that could feasibly be expedited, for example, reduction in safe infusion times.
- Implementing 'dynamic levels of care' relies on knowing which 'bundles' of care provide maximum effect for minimal cost. Retrospective analysis of injury patterns and the impact of resources applied at each step of the treatment pathway would inform setting of thresholds for retaining or removing these bundles as the situation dictates.

One of the extraordinary measures cited above is the initiation of reverse triage. This is a well-established concept whereby the least injured are treated first to return them to duty and free-up resources for the most critically injured. However, during the course of treating the least injured, it may be that some of the more severely injured will die before receiving care that would have been provided as a priority outside of MASCAL circumstances. Research and data-informed modelling should help UK Defence understand the thresholds at which reverse triage protocols are initiated, how tolerable this might be for wider society, and potential impact on the moral component of warfighting for SP. It is here that DMedC expertise in qualitative research and ethical decision-making should be brought to bear.

As discussed above in the context of blood supply, air superiority in previous asymmetric conflicts enabled rapid casualty evacuation from the point of injury to exquisite clinical care at role 2 and role 3 medical treatment facilities (MTFs). Evacuation timelines are likely to be profoundly different in future LSCO. The contested nature of the battlespace, including the constant threat of drone attack (see Box 8 Drone Warfare) means wounded personnel may have to remain in situ for several hours, or longer. Innovation in **prolonged casualty care** is crucial for physiology optimisation if we are to preserve life forward of substantive MTFs. There is no value in attempting to circumvent this requirement for innovation by introducing the notion of a 'golden day'; anatomy and physiology remain unchanged regardless of the operational context and the golden hour will remain critical[20].

d Distribute, decompress (discharge where possible), delay (defer treatment), dynamic levels of care, delegate (to the lowest capable provider), deliver faster (increased efficiency) and deliver better (increased efficacy), and de-escalate (back to normal procedures).

DMed must understand what can be done to mitigate the effects of prolonged timelines across the spectrum of care delivery from management of hydration and nutrition, prevention of pressure sores, through prolonged tourniquet application, to prevention of renal failure, coagulopathy, sepsis, and hypothermia. It is important to note that this is relevant not just to the land domain. For instance, prolonged care pathways already exist for long-duration submarine patrols and we must better understand how to mitigate against them, including management of complex wounds, burns, analgesia and palliative care within platform limits. Research efforts must focus on pushing intervention as far forward as it can feasibly be delivered. This will necessitate the development of techniques and equipment that can be used by non-specialist medics close to the point of injury, as well as self-administered interventions.

One area where this is particularly pertinent is in **non-compressible haemorrhage** (NCH)[e] which remains the leading cause of potentially preventable death in conflict. Despite significant improvements in combat casualty care, and reductions in overall mortality, patients with significant NCH face a high chance of dying from their injuries before they can reach a surgical facility. Existing management techniques typically require surgery or interventional radiology, conducted under general anaesthesia in a hospital setting, to enable controlled access to the bleeding vessel or organ and cessation of bleeding. In the deployed setting, evacuation to surgery has been the default means of definitively controlling NCH. Recent innovations in prehospital NCH control are either technically complex, requiring specialist administration (e.g. Resuscitative Endovascular Balloon Occlusion of the Aorta; REBOA), or require further evidence prior to their roll out into core capability (e.g. whether there is potential to cause collateral damage by cutting off circulation to uninjured extremities). Novel solutions are required that are deployable close to the point of injury, usable by non-physician medical providers, have low likelihood of iatrogenic trauma during application, minimise interruption of blood flow to non-injured structures, organs and tissues, integrate with existing workflows of casualty treatment, and do not threaten or complicate subsequent definitive surgery.

To intervene in the hours following trauma and potentially extend the survival window we must strive to better understand **trauma pathophysiology.** We should continue to unpick the mechanisms underpinning haemorrhagic shock and the inflammatory cascades amenable to novel anti-ischaemia intervention. What are the biological processes that underpin successful resistance to and recovery from haemorrhage, injury and tissue loss? How and why do these phenotypes vary, and how can this knowledge be leveraged? The pathways leading to septic shock and multiple organ dysfunction syndrome, specifically in the context of delayed treatment, require elucidation alongside mechanisms of trauma-induced coagulopathy.

e NCH refers to significant bleeding that cannot be immediately stopped or sustainably controlled from application of external pressure. It may arise from injury to blood vessels and organs within the torso (abdomen, pelvis and chest), or from the roots of the arms, leg or neck (junctional trauma, where the anatomical structures of the extremities join those of the torso). It could be due to bleeding from a large blood vessel, multiple small vessels or from organs such as the lungs, liver, spleen or kidneys.

We must understand how to avoid tissue hypoperfusion during prolonged casualty care and identify targets to reduce dysregulated host responses both in the acute phase, but also during secondary injury cascades after initial injury (e.g., inflammation and immune dysfunction, metabolic failure and mitochondrial injury, microvascular failure and organ dysfunction).

At the other end of the spectrum are the **long-term outcomes** of those sustaining combat injury. Longitudinal follow-up post service coupled with granular knowledge of exposures and activities in service enables us to pinpoint the optimal time for intervention and avoid life-long morbidity and reduction in quality of life.

The risk of thermal burns has been ever-present in Ukraine, with Russian forces known to have deployed incendiary devices early in the full-scale invasion[21]. Burn injuries cause significant physical disability and may lead to profound psychosocial and mental health impacts, yet the management of military burns is an under-researched area. A recent priority-setting exercise in burns[22] conducted for low and middle income settings identified research knowledge gaps in resource-limited civilian settings, which can be translated to guide burns research in military settings.

Improvements in acute **burns management** and evidence-based treatment strategies for austere environments are urgently required. This includes better informed resuscitation protocols, timing and type of surgical and medical intervention, and intensive care management. Interventions to improve burn symptoms – particularly pain – and the psychological impact of burns (e.g. the stigma around scarring) were prioritised and are also relevant to military settings. Specific to military burns, given the high potential of prolonged patient hold, DMed should investigate the impact of extended time to burn excision on healing, infection, problematic scarring, and time to return to full active duty. For major burns, research should investigate whether outcomes are improved (e.g., infection rates, ITU days, survival, morbidity, overall hospital stay) by early excision and matrix application prior to MEDEVAC. Furthermore, does immediate active trauma scar management plus or minus early laser treatment improve functional outcomes and reduce time to return to active duty? From a microbiological perspective, questions remain surrounding whether interventions targeting biofilm at initial debridement and at subsequent operations reduces wound colonisation, infection rates, and overall time to healing. Finally, in addition to thermal burns, chemical burns (e.g. caustic, sulphur mustard) and ionising radiation injury, or a combination thereof – are a persistent threat and work should seek immediate tissue damage limitation interventions, and seek to understand whether thermal burn management is an appropriate baseline for management of these specific burn injuries.

Damage control surgery (DCS) / damage control resuscitation (DCR) will need to adapt to remain effective in resource constrained environments. Forward surgical teams (FSTs) will require tactical and clinical agility to provide life-saving temporising care in heavily contested zones. Some features of DCR / DCS delivered on previous campaigns will be impossible to deliver promptly, consistently, and at scale in peer-on-peer conflict, and research should be directed towards novel interventions and therapies that are feasible and likely to have the greatest mortality and morbidity benefit in those surviving to reach Role 2 facilities.

Understanding what high impact interventions can be added to DCR that permit deferral of DCS and extension to clinical timelines is key, alongside exploring how we simplify complex surgical techniques for non-expert providers. Other specific questions include:

- What are the optimal blood, fluid, and vasopressor resuscitation strategies on the battlefield, and at role 2 in the context of LSCO? Is there a place for vasopressors to mitigate cardiogenic shock in trauma?
- How do we minimise blood product use without impacting outcomes? What is the role of crystalloid fluids in trauma resuscitation?
- Can patients with penetrating abdominal trauma and no features of shock or peritonism be managed non-operatively in forward locations?
- Can laparoscopic surgery be introduced into military care systems for abdominal trauma patients (with peri-operative partial REBOA to aid laparotomy in unstable cases)?
- What is the best way to manage abdominal closure post-DCS in the forward environment?
- Do patients with haemothorax benefit from auto-transfusion of salvaged blood?
- Are there medical countermeasures that can be used to alleviate limb-threatening tourniquet-induced ischaemia at DCS / DCR (pharmaceuticals, devices)?
- Does access to an AI tool help decision-making in borderline resuscitative or surgical decisions?
- Does the use of human acellular vein grafts offer advantages over standard prosthetic or autologous vein in limb-threatening vascular injury?
- What are the outcomes in patients with vascular injuries repaired by non-vascular surgeons?

Alongside questions around the formation, integration, and enablement of DCR / DCS teams:

- What does a minimum viable FST look like?
- How do surgical team numbers and composition affect quality of care?
- What factors enable DMed surgical / resus teams to effectively embed with Partner Force medical services?
- What factors enable DMed surgical / resus teams to effectively embed with host nation health systems?

The ability to provide safe and **effective analgesia** is a vitally important element of patient care. In previous conflicts, the delivery of effective analgesia has consistently lagged behind other advances in trauma care. How best to administer analgesia for the injured hypovolaemic patient remains a critical question due to concerns over the risk of adverse events. DMed urgently requires new analgesic options which do not confer the potential adverse effects of opioids but must be rapid to administer and effective in controlling pain.

Solutions must also account for delivery method, use by clinical and non-clinical providers, monitoring requirements, and logistical constraints. In the context of LSCO consideration must also be given to ensuring effective palliation of patients in which analgesia plays an important role. Ensuring a good death on the battlefield is an emotive topic, but one that must be given careful thought to ensure comfort and dignity of the individual and preservation of resource that might be life-saving for another.

Box 2
Complex wounds

Wherever man, warfare and organisms coincide, wound infection is apparent - Fleming, 1915

Conflict wounds often result in significant morbidity, even under operational conditions that allow a patient to receive exquisite care. Conventional weapons predominantly cause wounding via kinetic and thermal effect to skin, muscle, and bone. These wounds are likely to be numerous, large, and severe, with complex geometry, and with high levels of infection and other contamination. There is also evidence that they are prone to progressive tissue loss after the initial insult[23]. As described throughout this strategy, the environment in which wound care is delivered on LSCO is likely to be austere, sometimes extremely so, with long delays before patients can be evacuated to substantive healthcare facilities.

Despite advances in surgical and medical practices, conflict wounds remain challenging to manage from point of wounding, throughout the healing and reconstruction process, and into the areas of scar management and return to function. The potential delay to surgical management of complex wounds in future LSCO is particularly problematic given the progressive nature of tissue loss and increasing probability of transition from colonisation to infection, which is influenced by injury type, pathogen virulence, the presence of devitalised tissue, embedded foreign bodies, blood clots, and neurovascular injury. As such, novel interventions with a low logistical burden, that can be delivered by non-specialists, close to the point of injury, that prevent or mitigate tissue deterioration and infection are urgently required.

One factor that makes the development of these interventions particularly difficult is the lack of relevant biological models that reproduce the complexity of polytraumatic conflict wounds. The twin development of high-fidelity wounding models and novel treatment strategies is a key research priority.

Underpinning this modelling and intervention development should be a drive to understand patterns of wound infection sustained in previous conflicts, accounting for differences in operational environments. Comparison of these wound infection patterns and outcomes – what worked and what did not – across NATO partners with differing intervention strategies would inform effective management on future operations where such strategies remain feasible.

Conflict wound infections are not restricted to bacteria, and the management of invasive fungal infection must be considered. Likewise, although soft tissue infections predominate, attention must also focus on deep bone infections that can have major impact on long-term functional recovery.

The use of forward antibiotics as prophylaxis or treatment for infected wounds must be based on robust evidence-based guidance, accounting for time post injury, likely time to definitive treatment, and known patterns of antimicrobial resistance. As discussed under the Complex & Emerging Threats theme, bacteriophage technology may play a key role both in pathogen identification, treatment and re-sensitisation to antibiotics. Highly drug-resistant, virulent Klebsiella pneumoniae has emerged as a particular risk, while recognition of novel or rare patterns of resistance among Pseudomonas and Acinetobacter species also present treatment challenges[24,25]. A lack of appropriate diagnostics and a paucity of linked clinical outcome data will limit our understanding of the risk of wounds infected with multi-drug resistant organisms (MDRO) if steps are not taken to resolve them.

Mental Health

- **Prediction of psychiatric casualty rates in LSCO**
- **Early intervention in LSCO**
- **Optimisation of intervention for faster return to work**
- **Prevention and management of moral injury**
- **Military sexual trauma**

The mental health of SP continues to be of paramount importance to the DMedC and wider UK Defence. Of note is not just the number of people affected but the profound impact on the individual and their ability to perform their duty with the vast majority of all mental health downgrades being non-deployable (in comparison with approximately 1 in 3 MSKI downgrades).

Although we understand some of the drivers of mental ill health in conflict (role in theatre, time exposed to danger, length of deployment), these are derived either from contemporary asymmetric conflicts or historical accounts from the two World Wars[27]. To best prepare DMed for managing mental ill health in LSCO we must develop a **predictive model for psychiatric casualties** that accounts for a host of individual, organisational and contextual factors. These should include sociodemographic status, rank, age, gender, neurodiversity, time in and nature of combat, previous combat exposure, role / location, deployed mental health capability, cohesion, leadership, training / preparedness, and use of novel warfare techniques (see Box 8 Drone Warfare). By drawing on holistic inputs the model should allow determination of the proportion of those deployed who are likely to i) become a mental health casualty, including the type of characteristics and presentation, ii) require evacuation as a result of being a mental health casualty, and, iii) be able to return to frontline duty following in-theatre intervention.

Understanding the likely scale of the psychiatric casualty rate will allow UK Defence to develop **feasible early intervention** that can be offered close to the point of need. Forward psychiatry has been the intervention strategy of choice in recent conflicts[28]. This involves specialist psychiatric units operating 10-20 miles from the frontline to assess mental health casualties, intervene in mild and moderate cases, and evacuate those who need further management. This concept is presented with a fundamental challenge in contested environments where drones are the predominant threat. Evacuating casualties to the forward mental health team will be difficult, as will safeguarding the team within a distance that is clinically useful. Research must consider alternative methods for early intervention that can be delivered at scale and potentially by non-specialist providers. Ukrainian Armed Forces (UAF) use of trained chaplains and morale officers, as well as simple, practical, peer-delivered techniques, provide useful examples that should be further explored. Consideration should also be given to early interventions delivered by medical personnel who are not specialists in mental health, who may have to deal with large numbers of casualties in the forward-most established medical facilities. This includes the delivery of group interventions for personnel with acute stress disorder who may be returned to the fight.

Hand-in-hand with the requirement for feasible early intervention in LSCO is the need to **identify shortly after point of injury who is likely to recover in-theatre versus who will require rearward evacuation.** This is key to both optimising resource-usage (i.e. MEDEVAC capability) and maintaining the fighting force. Research efforts should focus on generation of a toolkit to help enable the assessment and triage of mental health casualties, potentially by non-specialist providers.

Beyond LSCO, almost half of those downgraded for mental ill health leave service within two years. A recent cross-sectional service evaluation within the Defence Centre for Mental Health (DCMH) showed only 44% of those referred were returned to service at the point at which the snapshot was taken. Research that helps Defence understand reasons for not returning to service, recovery rates per treatment delivered, and identification of individuals unlikely to recover earlier post diagnosis to better support their transition to civilian life would be valuable to the individual and the organisation.

Effective early intervention is as crucial in the firm base as on operations, but this relies on **identification of those personnel displaying early warning signs** for mental ill health before symptoms are severe enough to warrant medical downgrade. This will allow intervention, for instance, in those displaying emotional distress before it develops into mild Common Mental Health Disorder (CMHD), and in turn before mild CMHD develops into severe CMHD, a leading cause of mental health discharge. Other conditions of particular focus include depression, adjustment disorder, anxiety disorder and PTSD. The earliest point for identification and intervention is at Service entry. Based on the forementioned DCMH service evaluation, significant numbers enter Service with pre-enlistment self-harm behaviours, suicide attempts, and illicit drug use. This gives a clear starting point for early identification efforts.

There is no reason why Commanders cannot play a more active role in tackling sub-threshold mental health issues driven by loneliness, distress and low mood, prior to individuals being referred into the healthcare system (or at discharge from substantive care back to their Unit to prevent relapse), provided we understand how these interventions are best delivered. If individuals are referred onwards for further care, they can be offered waiting list interventions providing DMed an opportunity to rigorously assess the impact of social prescribing (e.g. sports, yoga, nature-based intervention). Further investigation into the efficacy of novel interventions delivered within DCMH is also warranted in addition to ***how* those interventions are delivered,** e.g. intensity, duration, setting. Internal data suggest that i) recurrent mental health problems are prevalent within the UKAF population and, ii) a large proportion of those referred to DCMH had a change of diagnosis whilst under DCMH care. Understanding how interventions can be better shaped in light of these factors is important.

Moral injury is a term used to describe the psychological impact of perpetrating or bearing witness to events that transgress one's moral code. This includes the inability to intervene to prevent or alleviate suffering, or perception of betrayal from within one's peer group or organisation. The likely scale of casualties during LSCO – both military and civilian – markedly increases the likelihood of SP experiencing moral injury, particularly those in medical roles that have grown accustomed to providing exemplary care for all patients in previous conflicts.

Research must examine how we best **prevent and treat moral injury** to avoid associated psychological consequences of guilt, shame, depression, self-harm, self-condemnation, anger and mistrust[29]. Areas to consider include organisational and leadership responsibilities, such as the impact of ethical leadership and moral / ethical training, plus non-clinical intervention. Further exploration is required to identify and measure the impact of morally injurious events among personnel presenting with mental health disorders, including but not limited to PTSD. Additional benefit would be found in identifying which specific components of existing therapeutic approaches are most effective in treating moral injury-related distress. DMed personnel are at high risk of moral distress and injury and should be a specific population of interest for research in this area.

Military sexual trauma (MST) – sexual assault or harassment experienced during military service – can result in a range of long-term mental health and functional difficulties[30]. MST represents a profoundly harmful and emotionally significant experience with far reaching implications for both the health of the individual, trust in the organisation and operational effectiveness. Recent DCMH data suggest approximately 9% of those referred for mental health treatment had experienced previous sexual abuse. Research is required to further establish the true prevalence and risk factors in the UK, to understand the barriers to reporting and help-seeking, and to define the range of psychological impacts of military sexual trauma, including PTSD, substance misuse and suicidality. Research would also inform preventative strategies aimed at leadership, organisation and culture, and identify the most effective interventions.

Box 3
Comorbidity of Mental and Physical Health Conditions

The prevalence of co-occurring mental and physical ill-health is substantial within the UKAF population, particularly in those downgraded for MSKI. Whilst this is well recognised, the direction of effect and how this directionality differs according to physical injuries being managed via PCRFs, RRUs, and the DMRC is less well understood. For example, it might be that during management in primary care low mood, apathy and avolition prevents engagement in MSKI rehabilitation programmes, reduces functional outcome prior to the end of the programme, and increases risk of further injury. By the time the patient reaches tertiary care the longevity and severity of their physical injury might prompt a downward spiral in their mental health.

Research is required to understand where the common clusters of mental and physical comorbidity lie, and which is driving the other across the various Defence rehabilitation environments. Once these facets are understood, efforts to pre-empt the establishment of mental ill health (or worsening of sub-threshold mental ill health) in those with MSKI, or MSKI in those with poor mental health should be prioritised, making use of self-guided, digital intervention highlighted with the Fit to Operate theme.

Box 4
Traumatic Brain Injury

Traumatic brain injury (TBI) is an umbrella term for acquired disruption of the normal function or structure of the brain, caused by a head impact or external force (including blunt force, penetrating injury, and blast). TBI can range in severity from mild, moderate, to severe, with classification based on neurobehavioural deficits and imaging post injury.

In recent years efforts have largely focused on mild TBI (mTBI)[f] or concussion, given its prevalence across allied forces in the Iraq and Afghanistan campaigns[31]. Despite significant investment in mTBI research in military and civilian contexts, key gaps in our understanding remain. The diagnosis of TBI on the battlefield is difficult; long-term outcomes can be poor despite a lack of initial symptoms, and early treatment options are limited.

Furthermore, untangling symptoms of mTBI from those of co-existing PTSD is often difficult, and crucial time for intervention can be lost waiting for symptoms to naturally differentiate. Management of mental health symptoms that are direct sequalae of brain injury may require a different approach given other comorbid cognitive, visual, and psychomotor deficits. Understanding the relationship between mental ill-health and mTBI is key; although contextual differences between diagnosis and management of mTBI in the UK and US should be borne in mind, the US TRACK-TBI study showed that one in five individuals experience a mental health disorder after mTBI, and the rates of completed suicide after TBI were almost three times that of the general population in these patients[32]. Links between pain, sleep disturbance, substance misuse and impulsivity and post-TBI suicidality warrant exploration.

There is also growing concern around the threat to brain health caused by blast exposure, mainly from weapon systems, particularly heavy machine guns and mortars. The recent Invicta Study[33] has shown measurable decrements in cognitive performance with chronic blast exposure along with evidence of direct injury to brain tissue in US personnel. The MOD is investigating whether similar effects are observed in UKAF personnel, again cognisant of contextual differences in e.g. firing range policy and behaviours, that might impact cumulative exposure. The development of portable magnetoencephalography (MEG) imaging capability should be exploited to elucidate the acute effects of exposure on brain function in high-risk environments.

[f]mTBI is not restricted to the Land domain. Shock and vibration experienced in fast boat transit may cause mild and moderate TBI and better mitigation strategies are required.

Unlike in mTBI, structural changes caused by moderate and severe TBI should be visible on computerised tomography (CT) imaging. However, the provision of CT close to point of injury will be heavily constrained in LSCO. This necessitates novel approaches to the diagnosis and differentiation of mild, moderate, and severe TBI that then informs the management strategy for the patient. Given the potential life-long implications of moderate and severe TBI, research should not neglect this end of the spectrum in favour of sole focus on mTBI.

f mTBI is characterised by transient confusion, disorientation, or loss of consciousness lasting not more than 30 minutes; is possibly associated with transient neurobehavioural deficits; and has a Glasgow Coma Scale (GCS) score no lower than 13.

Environmental Exposures

- **Prevention, assessment and management of injury associated with cold and heat exposure**
- **Rapid acclimation**
- **Altitude**
- **Medical materiel**
- **Occupational exposures**

The High North is of increasing strategic importance to UK Defence, particularly as climate change renders arctic regions more accessible for more of the year to allies and adversaries alike1. It therefore follows that we must be able to ensure temperate clinical practice can be translated into the extreme cold, underpinned by research that supports necessary modification and adoption. More specifically, the prevention, assessment and management of **freezing and non-freezing cold injury**[g] are central to the Defence Medical Research Strategy.

Mitigation of non-freezing cold injury (NFCI) begins at entry into service. However, it is reliant upon understanding peripheral vascular responses to cooling and subsequent rewarming in 'normal' (uninjured) individuals. A robust and validated methodology for testing and quantifying cold sensitivity can then be used to inform prevention and risk reduction. For instance, the extent to which recruits join the training pipeline with prior exposures that might place them at heightened risk of future injury is not known. Standardised neurological examination and evaluation of cold sensitivity in recruits and a matched civilian population would allow comparison of neural and vascular profiles. This in turn would enable UK Defence to understand whether any abnormalities are present prior to service-related exposure. Similarly, with a robust measure of cold sensitivity in place, efforts can be made to track a cohort of trainees before and after basic and advanced training. Within the Army, where prevalence of NFCI is highest, recruits are exposed to a homogeneous initial training program so UK Defence should be able to identify the aspects of training that have the biggest impact on neural and vascular function and whether some individuals are more susceptible than others.

There are also practical preventative measures that represent low-hanging fruit in this space. For instance, the use of small-packing shell / claw mittens over traditional gloves is one avenue for rapid exploration, including the impact on dexterity and task performance balanced against insulation. More broadly, how quickly SP demonstrate behavioural adaptation to reduce their risk of cold injury (e.g. knowing to remove and replace wet socks where possible), and how UK Defence can accelerate this adaptation is a key avenue for behavioural and qualitative investigation.

g Non-Freezing Cold Injury (NFCI) is caused by gradual, prolonged cooling of the hands or feet. It does not have to be freezing to get an NFCI; most cases occur in the UK during training. Freezing Cold Injury (FCI) happens in sub-zero temperatures and includes frost nip and frost bite. Parts of the body most prone to freezing are the extremities and exposed areas, e.g. nose, ears, fingers and toes.

Research Themes in Detail: Environmental Exposures

DMed must optimise the assessment and management of those with suspected cold injury via rigorous research to inform safe return to duty for those with known injury. The latter will depend on the availability of a laboratory-based cold challenge test, analogous to the heat tolerance testing already conducted, which can provide a rapid prognostic assessment of responses to cold stress. NFCI has a limited treatment profile, although recent attempts to counter neuropathic pain with capsaicin have shown promise[34]. This should be further explored alongside other curative measures.

Priorities in freezing cold injury (FCI) can be broadly split into recognition of potential cold weather injury (CWI) casualties in extreme cold weather (ECW) and the treatment of FCI far forward. Much like heat injury, below, it has been suggested that there is an association between declining cognitive function and increasing CWI risk. Further study could, for example, investigate the utility of the quick confusion score in cold-injured personnel as an indicator of need for evacuation. The effectiveness of iloprost (a synthetic prostacyclin analogue) as a forward treatment for FCI, and the manner in which it can be delivered safely and pragmatically (dosing, timing, logistical considerations) require urgent examination. It may be that forward management via early iloprost administration increases tissue salvage and negates the need for rearward evacuation, thereby preserving the fighting force.

Whilst the foremost concern is LSCO in cold environments, UK Defence cannot disinvest in research addressing **heat-related illness and injury.** Firstly, exertional heat illness (EHI) - caused by the body's inability to cool down during intense physical activity – can be experienced in any environmental condition. Secondly, the level of extreme 'heat stress' experienced across Eastern Europe continued to rise in 2025 and is expected to continue its upward trajectory[35], whilst UKAF will continue to deploy to tropical regions for training and live operations.

The primary prevention of heat illness is key in maintaining the health of the fighting force. However, Wet Bulb Globe Temperature (WBGT), the primary measure used to assess risk caused by environmental heat, was developed in dry desert conditions and remains relatively unvalidated in temperate climates. Its utility in predicting heat illness in these conditions needs to be better interrogated. Indeed, the aetiology of environmental (i.e. non-exertional) heat illness in the service population is poorly understood. Risk factors, pathophysiology, and disease trajectory described in the literature are based on populations at extremes of age and / or with comorbid medical conditions. Even where risk predictions are made, the risk evolves over the course of an activity. Recent work within an arduous military training setting has shown the importance of non-traditional risk factors including recent vaccination, symptoms of infection, and anxiety, each of which warrant further study. The potential for novel biosensors and wearable technology to inform predictive models requires additional evaluation. Tools to assess the risk imposed by, for example, encapsulating dress states are also required (see the CBRN PPE topic under the Complex & Emerging Threats theme).

From a diagnostic perspective, tools and methods to define heat illness severity more accurately and quickly must be developed, with the capability to differentiate heat illness from fatigue, hyponatraemia, and syncope. Once diagnosed, research must objectively assess the performance and tolerability of cooling measures, and how UK Defence best manages the EHI casualty after cooling.

Triage for evacuation priority in high threat or low resource settings should be modelled and validated, possibly via physiological criteria. It is also important to understand the extent to which relevant hyperthermic conditions can be managed in common: drug-induced hyperthermia, malignant hyperthermia, burns and heatstroke (exertional and non-exertional).

Finally, the long-term risks after sustaining an episode of mild versus severe heat illness need to be better characterised, including 'sub-clinical EHI' as a potential risk factor for more severe future illness.

Acclimation[h] is one technique shown to mitigate risk of EHI and environmental heat illness. It refers to repeated heat exposure that increases whole-body temperature, stimulates profuse sweating, and stresses the cardiovascular system, leading to increases in blood volume, decreases in core and skin temperatures, and molecular adaptations that stimulate sustained physiological changes. However, this is often conducted in graded sessions over the course of many weeks[36] which is unlikely to be feasible in LSCO. Research must examine how this process can be compressed whilst maintaining safety of the individual and sustainability of the effect. The ability to discern completeness of acclimation is in itself worthy of further investigation and should consider the impact of subjective reporting e.g. the danger of a service person's perceived reduction in risk being disproportionate to their stage of physiological adaptation. There is also potential for acclimation to be combined with prophylaxis, e.g., via supplementation, to support biological sites subject to compromise under heat stress. e.g., gastrointestinal tract epithelium, sarcolemma, and blood brain barrier.

Altitude is currently under-researched within UK Defence despite the clear drivers to concentrate further effort in this area. The immediate threats (e.g. Russia) and regional disruptors (e.g. Iran) specified in the SDR both have significant regions of high altitude, including those forming natural borders that may well become contested spaces at significant terrestrial elevation. Altitude acclimation and acclimatisation are therefore prioritised alongside heat: what is the minimum duration in a hypoxic chamber that confers meaningful effect? How long does it last? How many people could feasibly be meaningfully exposed in short order? Are there portable alternatives to hypoxic chambers that generate similar impact? These questions sit alongside others around the identification of individual risk factors for altitude sickness, and treatment of its effects.

The impact of cold on the service person and medical provider is critical, but Defence must also understand the implications for **medical materiel** crucial to patient care. This topic will require significant interdisciplinary collaboration across medicine, engineering, chemistry, and physics. For instance, the impact of extreme cold on dressings and adhesives – e.g. those used in chest seals – is unknown. The effect of freeze-thaw cycles on plastics – including tourniquets – is also poorly understood. Further work should be undertaken to determine if all plastics become brittle or if there are exceptions that may be suitable for ECW patient care.

h The terms acclimation and acclimatisation are often used interchangeably. Here, 'acclimation' is used as it specifically refers to rapid, controlled adaptation outside of the real-world setting, whereas 'acclimatisation' refers to natural adjustment through prolonged exposure. The latter is unlikely to be possible prior to deployment on LSCO.

Research Themes in Detail: Environmental Exposures

Drug storage, preparation and efficacy in ECW all warrant investigation, including:

- The impact of freezing (cryoconcentration, cryoprecipitation or isomerisation) on drug structure and efficacy.
- Drug reconstitution requires liquid solvents which are liable to freeze. Further work is required to understand if solvents can be utilised after freeze-thaw.
- The impact of the extreme cold on oral mucosal blood flow relevant to orally administered medication.
- Efficacy of intramuscular (IM) and intraosseous (IO) medications in ECW. Intravenous access requires significant skin exposure. Alternative routes such as IM and IO administration may be preferred to protect the casualty but IM / IO absorption requires further research.

Similar issues affect blood and blood product storage and administration where current storage systems are designed to prevent blood temperature excursions in extreme heat. Further study is required to review how we prevent blood freezing in storage systems and administration sets, including novel blood products in development that rely on liquid reconstitution. Until our understanding of the impact of freeze-thaw on drugs and blood products is improved, UK Defence must look to technology to mitigate significant thermal effect.

Whilst exposure to cold and heat are almost universally important to the UKAF population there are also **occupational exposures** that exert pressure on the health of specific groups[i].

Whole Body Vibration exposure continues to pose challenges particularly to fast boat personnel, users of armoured fighting vehicles / personnel carriers, and rotary wing aircrew. Future efforts to mitigate exposure must build on existing work that seeks to better understand mechanisms of injury, epidemiology, exposure monitoring, and impacts on cognitive and physical performance.

Submariners are subject to unique occupational exposures that warrant sustained investigation to determine long-term impact[j]. These exposures include atmosphere / air quality and operational contaminants, chemicals associated with systems and maintenance practices, light deprivation and vitamin D deficiency, demineralised water, constrained diet, noise and vibration, and ergonomic and space constraints. Profiling and mitigating these exposures should form the backbone of near-term collaboration between the DMedC and the Submarine Service.

i The challenges around occupational exposure to blast are covered in Box 4. Traumatic Brain Injury.
j Submarines represent a distinct operating environment characterised by prolonged confinement and isolation, high operational tempo, constrained medical capability, and unique occupational exposures. These factors shape health risks, clinical presentation, and the feasibility of prevention and intervention approaches, and warrant explicit consideration across the Defence Medical Research Strategy domains. This is particularly relevant to CASD as a critical, enduring no-fail Defence capability. Detailed submarine-specific needs, gaps, and prioritised research questions will be set out in the Submarine Health Research Strategy led by the Submarine Health Research Group (SHRG).

More broadly, it is increasingly important that in-service exposures can be linked to long-term health outcomes. Without robust longitudinal study underpinned by granular understanding of the stressors and exposures faced by a service person it is impossible to answer questions that arise many years post service. Only through prospective research can UK Defence unpick linkages between exposures (radiation, exhaust fumes, noise, vibration, altitude, pressure) and the development of long-term conditions. This is as important to protect future SP from potentially avoidable harm as it is to those in the veteran community who seek to better understand the impact of service on their health and wellbeing.

Box 5
Combat Casualty Care in the Cold

Cold injury – both freezing and non-freezing – is one important factor to be considered when operating in ECW. However, DMed must also be prepared to deal with combat casualties in extreme cold environments, which are inevitable when warfighting at scale, with implications for both the patient and medical provider (in addition to implications for medical materiel).

Starting with the assessment of casualties, traditional assessment methods require exposure of casualties which, in ECW, could be fatal. Training methods must be reviewed to ensure they are suitably adapted to delivering appropriate care that mitigates further thermal injury to both casualty and provider. The 8Ds of mass casualty (MASCAL) response discussed within the Combat Casualty Care theme include a framework for dynamic levels of care based partly on patient triage. How multiple patients are rapidly and accurately assessed in the context of ECW MASCAL scenario requires investigation.

Hypothermic casualties require active warming strategies to mitigate heat loss and promote heat gain. Warming methods when wearing wet and dry clothing need to be understood as well as the location of warming devices, e.g., generalised or junctional placement. Whilst warming is key, we must also be mindful of the increased thermal signature that it produces and understand how best to shield this to reduce detection.

In terms of treatment of the combat injury in ECW, tourniquets offer effective peripheral haemorrhage control when used according to doctrine. However, studies must enable us to better understand how we identify major haemorrhage in ECW PPE, how effective tourniquets are at controlling catastrophic haemorrhage when applied over clothing, and how readily they can be applied in ECW PPE / glove systems. Ventilation of casualties in the prehospital space may necessitate the use of air that is not warmed. The thermoregulatory impact of cold air on the upper airway is unknown.

Finally, further study is required to understand the optimal method of evacuating patients in ECW environments whilst providing viable methods for monitoring and treating patients en route.

Infection

- **Diarrhoeal disease**
- **Antimicrobial resistance and stewardship**
- **Syndromic surveillance**
- **Prevention / management of common notifiable diseases**
- **Vector-borne diseases**
- **Skin and soft tissue infections**

Diarrhoeal disease or traveller's diarrhoea (TD) has been a recurring threat to UKAF personnel across multiple recent deployments with alarming impact on operational effectiveness[37,38,39]. UKAF personnel deploy to areas in Africa, South-East Asia, and Central and South America with a substantial risk (≥20%) of acquiring TD[40], which is heightened by the close proximity in which personnel live for prolonged periods, whether in barracks or on ships[41]. Data from tours of Afghanistan show that 40% of troops questioned reported at least one episode of TD[38], with diarrhoeal disease being the second most common cause of field hospital admittance from 2005 to 2013[42].

Given that timely and effective treatment of TD could result in a 50%–70% reduction in illness duration and operational days lost[43], treatment – and prophylaxis – are enduring research priorities. Previous attempts to prevent and treat TD on operations have been restricted by intensive treatment regimens. Future experimental trials should choose therapeutics based not just on their efficacy profile but also on how feasible it would be for SP to complete the course of medication in realistic operational contexts.

In addition to preferences around prophylaxis and treatment, we must also better understand the drivers of TD within the deployed population; this is difficult when observation of hygiene practices almost always results in their improvement. One way around this is to implement an anonymised knowledge, attitudes and practices survey of the population at risk. This would identify hidden drivers of disease linked to understanding, perceptions, and behaviours, to enable more effective prevention strategies to be instituted.

Conflict is a known driver of **antimicrobial resistance** (AMR) for a variety of reasons[44]: damaged water and sanitation infrastructure; degraded healthcare and laboratory facilities; disruption to infection prevention and control (IPC) and public health activities (e.g. vaccination); limited antimicrobial stewardship (e.g. use of broad-spectrum antibiotics, fragile supply chains); forced migration and increased health needs. In a military context, when casualties arrive at Role 3 and 4 hospitals, patient isolation is constrained by limited space, there is little to no capacity to screen for MDROs, and antimicrobial formularies are restricted.

AMR in the context of conflict wounds is a profound issue that deserves urgent action (see also Box 2 Complex Wounds for the challenge of managing co-morbid polytrauma and infection). In Ukraine, MDRO infection of wounds has been shown to increase length of recovery, morbidity and mortality of injured personnel. This is likely the result of numerous factors, including limited early wound irrigation and debridement,

prolonged use of broad-spectrum antibiotics, extended casualty evacuation timelines and lack of IPC measures. Of particular concern is the role of resistant gram negative and hypervirulent organisms (e.g. Klebsiella pneumoniae) complicating traumatic wounds. Given similar factors are envisaged in future conflicts, managing wound infections will be a key concern.

Promoting better **antimicrobial stewardship** in both the firm-base and deployed healthcare is key to preventing the continued spread of conflict-related AMR. DMed should strive to understand how antimicrobial prescribing can be reduced, the unique drivers for seeking and prescribing antibiotics in SP and clinicians, the opportunities, enablers, and barriers to AMS, the role that point of care testing can realistically play, the carriage rate of drug-resistant organisms in our population in the firm base and living / deployed overseas, and whether empirical antibiotic guidelines are suitable for these populations.

During the conflicts in Iraq and Afghanistan both the UK and US saw significant MDRO challenges, particularly with Acinetobacter baumannii infecting combat wounds[45]. It was initially thought that this was from the environment at point of injury, but numerous studies showed it was linked to the use of broad-spectrum antibiotics for prolonged periods and, crucially, nosocomial transmission at healthcare facilities throughout the evacuation chain[46]. These findings highlight the importance of good antimicrobial stewardship (AMS) and IPC measures which will be even more critical in peer-on-peer conflict with extended and complex evacuation routes. UK Defence must invest in research that minimises this risk through novel diagnostics, surveillance, AMS promotion, and therapeutics (including vaccines).

Infectious disease surveillance continues to be a key mitigation of the risk posed to operational effectiveness. However, current systems rely solely on primary health data which, while near real-time, do not exploit all available data sources, require intensive resourcing, do not link to formal risk assessment outcomes, and would be difficult to scale in LSCO. To conduct better **syndromic surveillance,** efforts should be made to fuse multiple sources of health protection data to enable quicker decision making and more accurate prediction of risk. Integration of diverse infection data sources should significantly improve the speed and accuracy of threat detection, assessment, and prediction thereby improving force health protection. Currently under-utilised sources of data include laboratory clinical data, prescribing data, wastewater sampling (coincidentally also a source of phage), and use of syndromic read code groupings. Wearable technology that monitors physiological markers and provides pre-symptomatic signals of possible infection also offers a novel avenue for exploration. Research should be undertaken to determine how these sources are best fused, likely relying on novel machine learning techniques. In turn, this will overcome limitations of under-reporting by health professionals, and reduce the requirement for manual, timely, careful and skilled interpretation of data to inform subsequent decision making.

Research efforts should focus on those infections that demand the most resource and exert the greatest impact on force readiness. Here, examining the most common **notifiable diseases** is instructive: respiratory infection, sexually transmitted infections, undifferentiated febrile illness, and gastrointestinal disease (see above)[k] . The DMS must advance its understanding of gaps within prevention and management of these diseases to improve epidemiology, practical connection with force health protection actions, and the impact and importance of Chain of Command involvement. For respiratory tract infections (RTIs) specifically: what are the drivers of RTIs in SP at role 1 and role 3 MTFs? What vaccines should be offered to deploying troops and how does Defence increase uptake? What range of respiratory pathogens must be diagnosable on deployment? Furthermore, relative immunosuppression induced by arduous training or military deployment may increase an individual's susceptibly to, and modify their response to, infectious pathogens. As such, a better understanding of the underlying mechanisms and of the mitigations to prevent this (including improving host immune responses) is required.

UKAF will continue to deploy to areas of high-risk for **vector-borne disease.** Indeed, with climate change accelerating the spread of vectors to ever more temperate climates, Defence must be prepared for potential increases in related diseases . There are emerging threats from malaria, arboviruses (dengue, Zika, chikungunya, West Nile virus), helminth, and other high-threat zoonotic and neglected tropical diseases (e.g. human brucellosis, Q fever; leishmaniasis, schistosomiasis). Threat increase is caused not just from growing geographical vector spread but from evolving resistance, and a lack of vaccines, early diagnostics and effective therapeutics. From a systems perspective, Defence must also be better able to manage returning traveller health from regions of high risk.

Viral haemorrhagic fevers (VHFs) continue to pose a threat to UKAF deployed in regions of high risk (East Africa, West Africa, Eastern Europe). There are gaps in the licensed therapeutic profile for VHFs (e.g. Crimean-Congo Haemorrhagic Fever; CCHF), and major gaps in systematic screening and development of monoclonal antibodies (mAbs) across CCHF, Marburg Virus Disease and Lassa Fever. Supportive care is poorly optimised, particularly for loss of haemostasis which is central to mortality and an important route to novel host-directed therapeutics.

Skin and soft tissue infections (SSTIs) are often caused by Staphylococcus aureus or Streptococcus bacteria entering via broken skin. They can range from mild (e.g. cellulitis) to severe, life-threatening conditions (e.g. necrotising fasciitis), requiring rapid surgical intervention. Even in mild disease, a service person is unlikely to be deployable due to pain, swelling, blistering and reduced function. SP are at particular risk of SSTIs given the physical nature of the activities they engage in.

K In England there is a statutory requirement under the Health Protection (Notification) Regulations for all registered medical practitioners to report notifiable infectious diseases to the UK Health Security Agency. MOD policy requires its clinicians to notify the Defence Public Health Unit (DPHU) in addition to UKHSA for the purposes of coordinating a military health protection response. MOD additionally includes the requirement to report infections of military significance including cases of influenza like illness, non-specific gastrointestinal infections and cases of PVL Staphylococcus aureus

This increases both the likelihood of broken skin allowing bacteria to enter, and the susceptibility to SSTIs associated with immunosuppression. There is a continued trend of higher-than-expected SSTIs in Defence settings and the emergence of more virulent and persistent disease with greater AMR. Specifically, prevention and management of Panton-Valentine Leucocidin Staphylococcus aureus (PVL-SA) must continue to be prioritised within Defence research activities. It is essential that research in this area is behaviourally and culturally aware, given the increased prevalence of infection within specific demographic groups. There are also specific questions related to SSTIs (trends), and indeed wider infection (outbreak recognition, feasible diagnostics), that must be addressed in personnel exposed to closed and isolated platforms, such as submarines.

Box 6
Deployed diagnostics

The need for forward diagnostics cuts across many areas of this Strategy. The common thread between them, whether for diagnosis of TD, malaria, wound infection, or a CBRN casualty, is the requirement for devices or techniques that are sensitive, specific, and robust enough to be operated in all environments, potentially by non-specialist users.

The diagnosis of wound infection close to point of injury is critical to appropriately target antibiotics or other treatment strategies. For TD, management is typically symptom-driven in the absence of forward diagnostics, which is prone to type I and type II error when recommending isolation and reduction of duties. In the CBRN environment, diagnosis is also currently syndromic but with the added complexity that symptoms are similar across agents and the presentation might change from hour-to-hour; not to mention practical limitations around medical personnel and patients being in CBRN PPE.

Novel molecular and other emergent technologies should be investigated to broaden the range of detectable pathogens and extend beyond simple diagnostic application e.g. to understand pathogen transmission dynamics.

Experimentation with agnostic clinical metagenomics is crucial as these capabilities have the potential to provide the next level of diagnostics in the deployed space, including the identification of resistance mechanisms, emerging biological threats (e.g., ‘Pathogen X’) and novel biowarfare agents in the CBRN space.

Finally, CT imaging is central to the management of critically ill patients following traumatic injury. For example, localisation of the source of bleeding in the abdomen or chest will direct subsequent surgical approaches whilst detection of significant intracranial injury will guide the type of therapy required (see Box 4 Traumatic Brain Injury). However, access to CT is unlikely to be universal in LSCO, given traditional placement within large-scale MTFs, the need to manage critically injured patients in the prehospital setting, and where the number of casualties overwhelm the capacity for axial imaging. As a result, alternative diagnostic approaches – possibly relying on validated, polytrauma point-of-care ultrasound protocols – are urgently required.

Complex & Emerging Threats

- **Chemical, Biological, Radiological, and Nuclear medicine**
- **Combating engineered resistance**
- **Bacteriophage technology**
- **Novel weapons bioeffects**
- **Optimising personal protection**
- **Contested medical care & evacuation**

One of the five pillars of FMedOpC25 is the need to prevail against future threats. These threats are significant and wide-ranging, spanning climate change, AMR, nefarious use of synthetic biology and artificial intelligence, CBRN and novel weapons, and the erosion of humanitarian law in targeting of healthcare facilities. UK Defence medical capability plays a central role in preventing, protecting against and recovering from many of these threats. It is therefore crucial that DMed continues to work with allies and partner organisations to drive research and development activity.

The global **CBRN** security environment has changed dramatically over the past decade with continued attempts to undermine global norms against the proliferation and use of weapons of mass destruction by both state and non-state actors[48]. An issue of primary concern is the use of synthetic biology to enable an agent to evade detection and prophylaxis measures and resist further treatment. The 'unknown threat' requires urgent research and development efforts across surveillance, diagnostics, agile platform vaccines, and novel and repurposed medical countermeasures (MCMs[I]).

Priority MCMs for Chemical threats include sequestration agents to encapsulate or degrade the chemical agent, antagonist additives against pharmaceutical based agents (PBAs) that can be delivered at scale, and lipid rescue in nerve agent toxicity. Efforts should also be focused on attempting to establish common antitoxin pathways cognisant of the breadth of toxin exposure that UKAF might potentially face, and the development of point of incidence testing that can be coupled with syndromic assessment for acetylcholinesterase activity.

UK Defence should continue to invest in the development of first aid measures for injuries and burns caused by chemical agents and chemical weapons. This should include measures for solid, liquid and gas chemical agents (i.e. to treat cutaneous contact, mucous membranes and inhaled substances). How best to decontaminate a CBRN wound or a combat wound in a CBRN environment also warrants further investigation.

I The information contained within this section is restricted to OFFICIAL, as per the classification of the Research Strategy. This allows wide distribution to partners outside of Defence. More specific detail on CBRN research priorities can be provided on request to those with appropriate clearance.

CHEM

- Markers of sub-clinical chemical exposure.
- Pharmacological treatment for chemical agent induced acute lung injury.
- Sequestration in nerve agent toxicity

BIO

- Enhanced screening capability at the point of exposure and within deployed MTFs.
- Pre- and post-exposure medical countermeasures to counter the threat of bioengineered resistance to first line therapeutics.
- Novel therapeutic adjuncts (phages, monoclonal antibodies).

RAD/NUC

- Acute Radiation Syndrome radioprotectants.
- Dose assessment, effect prediction and triage.
- Radiotherapeutics.
- Decorporation therapy.
- Management of local and combined injury in a radiological environment.

X-CUTTING

- Psychosocial effects and risk communication.
- Optimisation of PPE and interoperability including biological / radiological particulate protection.
- Optimisation of CBRN medical training and simulation.
- Scalability of medical care.

From a Biological perspective, agents that drive high mortality, with potential for aerosolised release and person-to-person transmission, represent key threats. In a deliberate release event, there is unlikely to be time or capacity for gold-standard diagnosis (e.g. formal microbiological culture) hence improvements in rapid diagnostic capability are required that are able to detect multiple biological agents. Naturally occurring multi-drug resistant organisms (MDROs) have reduced antibiotic susceptibility. This is compounded by the potential for biological agents to be **engineered to resist** traditional diagnostics and treatments. Novel therapeutics (antimicrobials, antivirals, mAbs) must be developed given the likely resistance profiles that would be encountered. Transmission models must also ensure that they are sensitive to shifts in transmission dynamics related to AMR variants and not solely natural strains.

One route that should be explored to address rising conflict-related MDROs is **bacteriophage technology**. Bacteriophage – or phage – are viruses that specifically target and kill bacteria regardless of whether those bacteria are resistant to antibiotics. As well as being used as substitutes for antibiotics, phage can also be used to diagnose pathogens that evade traditional diagnostic techniques and as biodefence agents.

Phage can be used for…		
Tackling MDROs by…	Diagnostics by…	Biodefence by…
Being specifically tailored to the infecting pathogens as single-phage or phage cocktails.	Leveraging their exceptional specificity towards the bacterial host, distinguishing not just species but specific strains of bacteria.	Detecting biothreat agents.
Penetrating and disrupting biofilms leading to enhanced adjunctive antibiotic efficacy.	Being integrated into biosensors or acting as ‘reporters’ by generating a fluorescent signal after infection of the target bacteria.	Neutralising biological threats, including those posed by aerosolised agents.
Degrading resistance conferring plasmids to support horizontal gene transfer and disrupt AMR.		Combating engineered resistance in deliberate release scenarios.
Being impregnated into bandages and dressings, or formulated as foams, gels, and sprays that are stable for prolonged periods and suitable for use on human tissue and clinical surfaces.		Decontaminating surfaces, air, and water exposed to bacterial threats.

However, there are a host of challenges associated with phage technology that must be addressed before widespread research use, let alone clinical use. Firstly, there are regulatory challenges around Good Manufacturing Practice-compliant production of phage, given the required specificity based on pathogen susceptibility. Secondly, there is a lack of evidence around the dose, concentration, route of delivery, and monitoring requirements; existing evidence relates to chronic infection rather than acute trauma. Thirdly, there is a lack of sovereign infrastructure to select and produce timely, quality assured products. Fourthly, there is no diagnostic standardisation or validation criteria for phage selection, susceptibility testing, or anti-microbial interaction testing. Finally, DMed lacks access to clinical or academic phage libraries for relevant biowarfare pathogens.

These challenges are not insurmountable with collaboration across government departments, civilian academia, and NATO allies. This Strategy gives a mandate to pursue phage as a feasible potential solution against the threat of AMR in the military context.

MCMs for Radiological and Nuclear threats warrant greater research attention, but must be underpinned by a robust casualty estimate across military environments and activities. Sensitive detection and monitoring capabilities to allow dose assessment and triage of cases is another route to pursue. Crucially, efforts should be made to build capacity for Radiological and Nuclear research working in tandem with partner organisations.

Refreshing UK Defence’s understanding of the interactions between conventional pharmaceutical agents, CBRN threats, and MCMs represents low-hanging fruit that would inform prophylactic and therapeutic decision-making.

Personal protective equipment (PPE) is a critical MCM and the primary means for protecting UKAF personnel against direct CBRN threat. To provide optimal protection to all SP in all environments Defence must better understand the challenges presented by extremes of weather (cold, hot, wet / humid, wind, dust) and additional considerations around gender (anthropometric fit, allowance for menstrual hygiene measures), religion and culture (dress, headwear). To take heat as an example, CBRN dress state 4 is a fully encapsulated ensemble with work-rest schedules imposed on operators to prevent hyperthermia and dehydration. However, there are variations within and between individuals as to tolerable thermal strain that current measures cannot account for. Understanding this variability – and the end-organ effect and related cognitive performance – will enable better mitigations to be implemented to safeguard CBRN operations (see Environmental Exposures for more on heat illness).

The Defence Command Paper refresh in July 2023 highlighted the need for the UK to innovate and invest in novel weapons, specifically directed energy capabilities[49]. The intervening years have seen the development and testing of DragonFire – a high energy laser – prior to its delivery to the Royal Navy in 2027[50]. UK Defence must keep pace with its adversaries in the development of novel weapons. Crucially, it must also ensure understanding of the **bioeffects of novel weapons**, that is the mechanisms and patterns of injury associated with both occupational exposure and enemy action, develops in parallel with the capability. For instance, what distances represent accurate thresholds for skin and ocular hazards? How should personnel be protected from injury within those parameters? How does the population at risk and magnitude of injury differ based on the broader scatter of a reflected beam? Is ocular damage immediate or progressive, and if progressive, over what time scale? Addressing these questions would enable proportionate management of risk as directed energy weapons are further rolled out.

Personal protection – the equipment used to protect SP from enemy action – will be a key mitigation not just against the bioeffects of novel weapons, but also to counter the threat posed by high-energy explosives like those being used by Russian forces during their full-scale invasion of Ukraine.

Combat injury patterns in Ukrainian SP show the most common are injuries to the extremities, face, head and neck[51]. The mechanism of injury has shifted as the conflict has evolved and includes high-energy rounds, drone-dropped munitions, improvised explosive devices, and landmines. High-intensity modern explosives have rendered body armour less effective and resulted in increased numbers of critical abdominal, vascular, and head injuries. Thermobaric explosives are also contributing to combat-related injuries, including burns, blast TBI and pulmonary trauma[52]. The nature of thermobaric explosive weapons renders them effective at circumventing the protective effects of conventional body armour. Improved body armour systems that provide maximum coverage whilst maintaining mobility represent a key opportunity for injury prevention on the battlefield.

The delivery of deployed medical care in the context of LSCO will look very different to that of Iraq and Afghanistan and there is a need for research to support and shape DMed systems that are ready and can rapidly adapt. There will not be a hardstanding, sophisticated and highly specialised MTF akin to Camp Bastion. **Medical care and evacuation will be contested** and targeted by enemy action[53], casualties will be held in theatre for longer (see Combat Casualty Care theme), and care will be dispersed, delivered underground or in unmarked buildings of opportunity[54]. A lack of air superiority[m] will increase the importance of protected ground medical evacuation to allow patients access to timely damage control surgery. Here, lessons can be learned from Ukraine's use of rail to move casualties east to west. A maritime or airborne evacuation route would be required to extract casualties from mainland Europe back to the UK. Upon arrival it is highly unlikely that the Role 4 hospital in Birmingham would be able to manage enduring high numbers of casualties, necessitating dispersal throughout the country[18], including to sites that have not previously managed military patients.

This prolonged and contested care pathway is fertile ground for research and innovation spanning medicine and medical logistics. Specific issues include use of reversionary techniques when undertaking patient care (i.e. those not reliant on power and IT), measuring and preventing potential exposures when delivering healthcare in subterranean environments (e.g. radon, asbestos, biologicals), medical equipment that does not emit electronic signals, translation of lessons from the Nightingale concept developed during Covid-19 to expand emergency capacity, and education of civilian medical staff in managing injured combatants.

m Air superiority refers to the degree to which a side in a conflict holds control of air power over opposing forces. This can be quickly achieved in asymmetric conflict but is often not possible in peer-on-peer conflict.

Box 7
Mental Health in high-threat CBRN environments

UK Defence has recent experience deploying personnel to environments characterised by significant biological threat, most notably during the Ebola epidemic in West Africa[56]. Informal post-deployment accounts suggest that this mission generated considerable anxiety, particularly among SP whose deployment was directed rather than voluntary. Reported concerns included personal health risk, the practical management of that risk in austere conditions, the unfamiliar and potentially distressing experience of working with infected patients in-country, and the perceived risk of onward harm to family members following return to the UK. However, these observations remain anecdotal and have not been subject to systematic investigation or formal reporting. More broadly, UK Defence has comparatively limited recent operational exposure to high-risk chemical, radiological, or nuclear environments, aside from their involvement in the response to the Salisbury Novichok incident.

Evidence from CBRN-related research indicates that psychological impact is shaped not only by objective exposure, but by risk perception, uncertainty, quarantine or isolation measures, stigma, trust in leadership and communication, perceived organisational fairness, the cognitive and physical burden of prolonged PPE use, and anxiety associated with medical countermeasures and health surveillance. These factors may influence adherence, operational performance, help-seeking, and longer-term mental health outcomes, including persistent somatic and stress-related symptoms. The mental health implications of CBRN deployment across the pre-, intra-, and post-deployment phases therefore remain insufficiently understood within UK Defence. Targeted qualitative and longitudinal research is required to identify modifiable risk and protective factors and to inform evidence-based approaches to preparation, in-theatre support, recovery, and follow-up for personnel operating in high-risk CBRN contexts.

Combat Casualty Care

Box 8
Drone warfare

In Ukraine the ubiquitous and evolving threat is posed by drones[n]. Ukraine claims to have built more than a million drones in 2024[57], whilst Russia has launched 400–600 drones in a single day. Drones are reported to be responsible for up to 70% of all military casualties in that conflict[58]. At such a scale, the impact of drones is felt at both the individual and military health system level.

At the individual level drone-delivered weapons can cause more severe injuries that require different surgical management to explosives delivered by other mechanisms (e.g., aircraft, tank shelling, naval artillery)[59]. Recent reports have outlined the catastrophic facial wounds that result from drone-dropped explosives or direct collision; loss of both bone and soft tissue and wound tracts that completely transverse the face[60]. Research should investigate the protection from, and acute management, reconstruction and functional rehabilitation of these injuries and ensure this filters through to training and clinical guidelines.

There are psychological as well as physical consequences of drone warfare. The presence of a drone or multiple drones flying overhead produces anxiety in those below, who are unable to discern whether they are under surveillance or attack. Civilians and military personnel who live under the constant threat of drone attack report psychological difficulties captured under the term 'droneophobia'[61]; they suffer from anticipatory anxiety, burn-out, and features of PTSD[58]. How UKAF best prepares SP for the psychological burden of operating under the threat of enemy drones, and how this burden is remediated post deployment is a pressing research priority.

The psychological impact of drone warfare extends to those operating the drones as well as those targeted by them. Whilst arguments can be made that use of drones has enhanced pilot safety compared with traditional aircraft, drone operators experience unique stressors. These include the need to monitor the aftermath of an attack for prolonged periods thereby bearing witness to the death and destruction caused[62]. Research should continue to explore rates of psychological distress – particularly moral injury – amongst drone operators and interventions that can prevent the onset of chronic mental ill-health.

At the health system level, the ubiquitous use of drones raises questions around how casualties are reached, stabilised, and evacuated. What is the role of a Combat Medic or Role 1 GP that has traditionally provided forward care when mobility is denied by the drone threat? What is the role of a Role 2 surgical facility in a battlespace dominated by drones where the risks of rearward evacuation – and likelihood of secondary strike by loitering munitions – might outweigh potential benefits? On the flipside, how do we most effectively use drones to our advantage in this context? Research and innovation should continue to explore drone-based forward logistical re-supply and rearward casualty evacuation.

n The term 'drone' can cover aerial drones (uncrewed aerial vehicles – UAVs) which are the most prevalent type in use in Ukraine, maritime drones, and land drones (uncrewed ground vehicles– UGVs). Here, the term is used to describe UAVs unless otherwise specified.

Delivery of the Strategy

This Strategy presents a plethora of research priorities that will enable DMed to meet its most pressing challenges. The what has been set out in detail; this section discusses how this portfolio of activity will be best delivered.

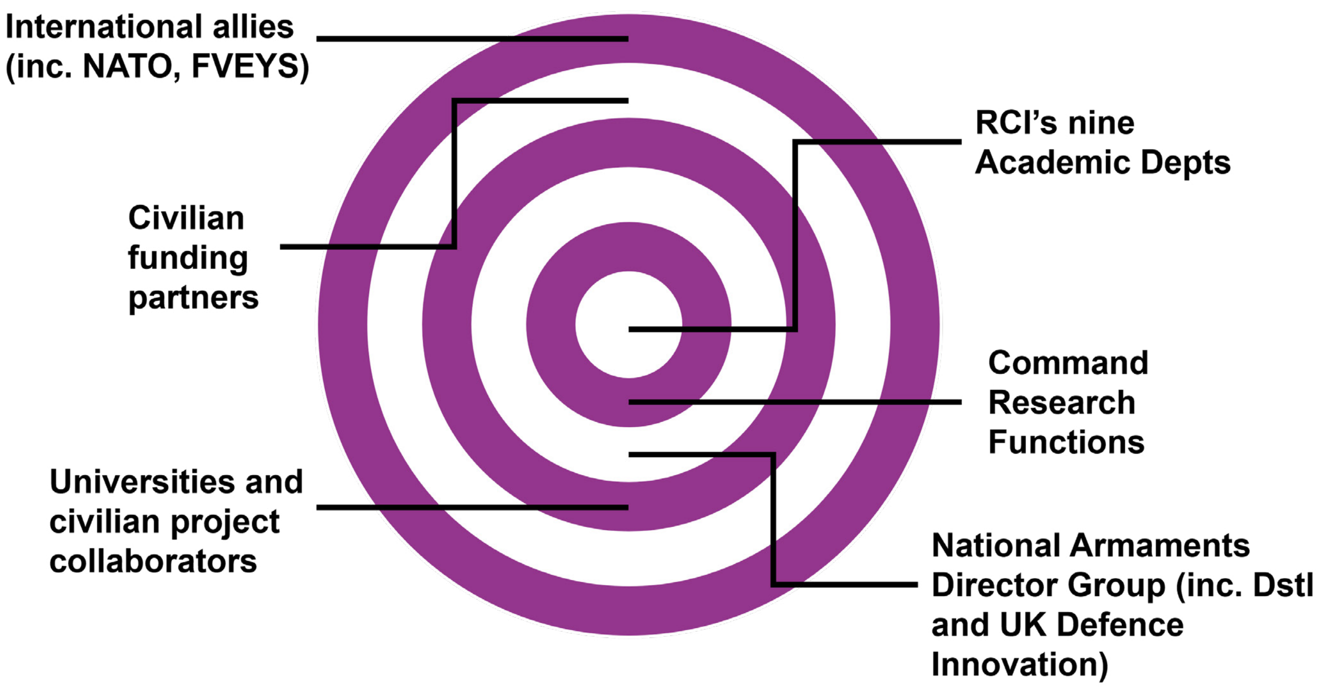
Working in partnership

MOD must develop closer relationships across the Science and Technology (S&T) ecosystem, especially with universities...

act as a gateway to academia and research institutions across the UK and allied countries, leveraging Government-funded, world-class S&T more effectively…

…share problem sets with academia and research institutions to develop their understanding of the problems facing Defence…

-Strategic Defence Review 2025



Collaboration at all levels is fundamental to the delivery of the Strategy (Figure 4). Starting closest to home, the breadth of topics necessitates cross-speciality and multi-disciplinary working across the nine **RCI Academic Departments**[o]. There will be questions, for example in syndromic surveillance, that require Primary Care to work closely with public and environmental health experts, where behavioural science is coupled with epidemiological modelling and serosurveillance techniques. Addressing wound infection priorities may bridge across surgery, orthopaedics, medicine, nursing, and pathology from fundamental mechanistic work through to long-term management strategies. No single Academic Department owns a research theme in its entirety. Research Theme Working Groups (RTWGs) will continue to bring coherence and foster collaboration across departments, keeping the research question front-and-centre.

TBI research within RCI has reached a point of critical mass with multiple high-profile and high-value projects underway. This strategic period will see the inception of the **Institute of Military Brain Health Research** (IMBHR). This new structure will lead and cohere Defence brain health research activity, including at the intersections of TBI and mental health, occupational exposures, and environmental insult. IMBHR will leverage existing infrastructure in place under the mTBI Predict and Brain Blast programmes (e.g., laboratory capability, imaging technology, data architecture) and will provide a focal point for UK Defence TBI research engagement akin to those in the US (e.g. TBI Centre of Excellence, Military TBI Initiative). Clinical TBI management will continue to be delivered as it is today, informed by the outputs of IMBHR programmes.

RCI has a specific remit to deliver medical research of military relevance. This does not mean that RCI is the sole organisation working in this space. Links must continue to be strengthened with **Front Line Command (FLC) research establishments,** particularly in areas of primary relevance to a single Service. There is no reason to duplicate the efforts of Army Recruit Health and Performance, for example, to reduce levels of MSKI in phase I training. RCI personnel will be available to provide the medical voice where required and FLC research personnel will continue to join relevant RTWGs to promote collaboration and reduce the chance of duplication.

The previous strategic period (2021-2026) saw a step-change in the depth of collaboration between DMed and the **Defence Science and Technology Laboratory (Dstl).** Building on the successes of DMed personnel completing higher degrees at Dstl, and bilateral input into respective programme boards and working groups, recent years saw the co-production of large-scale funding programmes that bridged basic and clinical research. The exemplar of this has been the Blood Product Translation Accelerator Programme (Blood on TAP) responsible for landscaping, developing and delivering a national portfolio of research to push ahead with the blood far forward agenda. Similarly, the Dstl-DMed Conflict Wound Research Network has identified stakeholder requirements in this complex space, provided seed-funding for numerous projects, and initiated a large external research funding exercise in wound modelling

o RCI Academic Departments span Anaesthesia and Critical Care, Emergency Medicine, General Practice, Medicine, Mental Health, Nursing, Rehabilitation, Trauma and Orthopaedics, and Surgery and Trauma.

and treatment. Many of the research priorities specified within this Strategy would benefit from this type of collaboration, ensuring Dstl activity is informed by the needs of the medical community (particularly the nascent Dstl longitudinal cohort study), and DMed research is able to make use of world-leading capability at Dstl. This includes Dstl's large animal trauma model that has underpinned progress in our understanding of resuscitation protocols, which must continue to be sustained and developed. Models that allow the elucidation of the aetiology and progression of complex polytrauma wounds (see Box 2), and the testing of novel wound treatments is a key DMed priority looking to the future of Dstl sovereign capability.

Alongside Dstl within the National Armaments Director Group (NADG) sits **UK Defence Innovation** (UKDI), a refreshed construct spun out of Defence Reform.
UKDI will become a key enabler and funder of later phase DMed research (i.e. Technology Readiness Level 6+) that has potential for rapid translation into the hands of the end-user. Links and collaboration between RCI Research, RCI Implementation, jHubMed, and UKDI will allow the early identification of projects with outputs ripe for rapid uptake, and ensure lines of responsibility remain clear. UKDI will also continue to present a viable route to market for military medical R&D challenges that are beyond our remit to tackle alone. From the previous strategic period, whole body vibration and non-compressible haemorrhage research were two such areas that required additional capability and expertise to that which existed within Defence. Where similar wide-ranging challenges emerge during this strategic period the same approach will be taken.

University partners are fundamental to the success of DMed research. Over the previous strategic period 28 different universities worked with DMed to deliver research projects and higher degrees. The quotes from the SDR above highlight the enthusiasm across Defence and wider Government for continued engagement with academia as part of a whole of society approach to meeting the nation's most pressing challenges. It is inevitable that injured service personnel become NHS patients at some point in the future, potentially upon evacuation to the UK in LSCO or upon discharge or retirement from Service. This Strategy gives the academic community a renewed demand signal to engage with DMed for the benefit of those who serve and the nation as a whole.

In addition to universities there are other organisations that enable the delivery of the research portfolio. Pertinent among these are partners that allow access to contexts and patient populations analogous to those DMed might encounter on future operations. Continuing to foster closer ties with, for example, the British Antarctic Survey Medical Unit, would enable realistic cold-weather research to be undertaken, in the same manner as successful existing collaboration with Air Ambulance providers across the UK to mimic forward casualty care environments.

The military medical challenges DMed are facing are not unique to the UK and we must continue to lead and engage with **international allies** via bilateral agreements and NATO and Five Eyes (FVEYS) mechanisms. This engagement must be focused appropriately to avoid spreading our capability too thin. Particular attention should be paid to those activities that impact on interoperability, including guideline development. Any change to the way DMed delivers care in extremis will impact allied forces personnel as well as our own. As such, MASCAL research is one area where NATO and FVEYS collaboration can truly bear fruit.

The themes and topics outlined in this Strategy are not just pressing medical priorities, they are also avenues of scientific interest in their own right. Elucidating the pathophysiology of trauma, for example, will improve our fundamental understanding of human biology and triggered cascades. Understanding pharmacogene expression in UKAF personnel will have broader implications for under-represented populations across the UK and beyond. Engagement of **civilian UK funders** (specifically research councils under UK Research and Innovation; UKRI, and the National Institute for Health and Care Research; NIHR) can therefore be founded upon not just a top-down Governmental drive to collaborate but also a desire to generate new knowledge. The refreshed UKRI direction sets out three R&D priorities, two of which are directly relevant to DMed research: curiosity-driven research and strategic government and societal priorities. It goes without saying that closer collaboration between UKRI and DMed would be mutually beneficial in achieving the aims of both organisations.

Internal Capability Development and Research Readiness

The biggest asset to Defence medical research is the people conducting it. We must continue to allow them the time to dedicate to research while being mindful of operational and clinical commitments. A crucial part of the offer to the uniformed medical research community should be to support them in the period after completion of a higher degree and before establishing themselves as research leaders. The opportunity to apply for joint NIHR-DMS Postdoctoral Fellowships will continue to be offered to those who are eligible and interested. It is important that Defence researchers are able to benchmark themselves against civilian peers and demonstrate the quality of work being undertaken within DMed.

Whilst the importance of conducting interventional trials of novel pharmaceuticals and devices is clear, DMedC does not have the capacity to meet the legal responsibilities required of a Research Sponsor for these activities. This is the case regardless of the context in which the trial is delivered, whether within Defence (e.g. a rehabilitation trial at DMRC) or outside of it (e.g. within the NHS). UK Defence must invest in this capability. There are studies addressing questions of military medical importance that simply cannot be delivered outside of Defence (e.g. due to security sensitivities), and others that demand military-specific outcome measures that could not be mimicked in a civilian setting.

Data is (or are) the foundation upon which robust research is built. In previous asymmetric conflicts it has taken too long to commence studies and rapidly exploit data that could have meaningfully improved patient care. This has been remedied in part over the course of the previous strategic period with policy put in place to mandate operational data capture on secure, electronic platforms. However, there is still work to be done to future-proof data capture on kinetic operations in denied environments. Developing offline case report forms that are harmonised with clinical procedures is key to collect the required minimum dataset without overburdening the clinician. It is incumbent on clinical and academic leads to determine which data would be most useful in advance of operations, and on commanders to ensure that these data are captured within their units. The more granular the level of data that can be collected – not just on operations but throughout a service person's career – the more accurately exposures, injuries, and outcomes can be mapped. It is important this is borne in mind when designing prospective data collection tools. Finally regarding data, it is imperative that DMed avoids learning lessons only from those personnel that survive to Role 4. Understanding how post-mortem data can be sensitively and accurately collected to avoid survivor bias and improve acute care of the most seriously injured warrants extensive thought.

Data preparedness is one way in which DMed can position itself to conduct research from day one of future operations. But this must sit alongside other efforts around proactive governance and assurance. We cannot afford to be developing protocols, securing funding, and seeking scientific and ethical review in serial once personnel have been deployed. The DMed academic community must strive to have oven-ready, approved protocols that can be initiated at pace when required. The organisations responsible for the assurance of such studies should give urgent thought to how their processes are streamlined and adapted to meet this need.

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