Defence Medical Rehabilitation Centre (DMRC) COVID-19 Recovery Service

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ABSTRACT
Coronavirus disease 2019 (COVID-19) causes significant mortality and morbidity, with an unknown impact in the medium to long term. Evidence from previous coronavirus epidemics indicates that there is likely to be a substantial burden of disease, potentially even in those with a mild acute illness. The clinical and occupational effects of COVID-19 are likely to impact on the operational effectiveness of the UK Armed Forces. Collaboration between Defence Primary Healthcare, Defence Secondary Healthcare, Defence Rehabilitation and Defence Occupational Medicine resulted in the Defence Medical Rehabilitation Centre COVID-19 Recovery Service (DMRC). This integrated clinical and occupational pathway uses cardio-pulmonary assessment as a cornerstone to identify, diagnose and manage post-COVID-19 pathology.

INTRODUCTION
Coronavirus disease 2019 (COVID-19) is a multisystem illness caused by a novel coronavirus, SARS-CoV-2. In the early stages of the global pandemic, the UK Armed Forces reduced non-essential tasks and stood up to support the national COVID-19 cross-governmental response, undertaking medical, engineering and logistic roles. These included supporting the establishment of the Nightingale Hospitals, delivering personal protective equipment and medical material and implementing oxygen delivery systems. Support was also provided to NHS leadership, while Defence Secondary Healthcare (DSHC) personnel delivered clinical services and liaison roles within their host NHS Trusts.

The medium-term and long-term impact of COVID-19 is unknown. Casuality estimates (Ministry of Defence/Defence Science Technology Laboratory Predictive model April 2020) initially predicted 5000 UK service personnel (SP) (10% severe) would be infected in the first 10 weeks of the pandemic. UK Defence Statistics has more recently published figures of 513 positive COVID-19 results from 27 674 tests, as at 11 September 2020.1 However, these figures rely on criteria for o and availability of testing, and SP informing the medical chain of civilian test results, so the true figure is likely to be higher.

COVID-19 presents significant challenges to the Armed Forces with further waves and spikes of disease expected. What is more, the inherent vulnerabilities of living and working in close quarters, as in traditional military settings, increases the risk to SP. A specific military COVID-19 medical response was developed, with Defence Primary Healthcare (DPHC) establishing a national network of Defence COVID-19 Bedding-Down Facilities for those too unwell to self-care but not unwell enough to require hospitalisation.

Defence Rehabilitation specialists at the Defence Medical Rehabilitation Centre (DMRC) Stanford Hall published a consensus statement, synthesised from a broad-based rapid review, on the specific rehabilitation needs of the post-COVID-19 population.2 Domains covered included pulmonary, cardiac, neurological and exercise rehabilitation. This process informed the content of a 2-week residential rehabilitation course offered to all SPs who are struggling with prolonged symptoms after COVID-19.

The majority of DSHC physicians have managed patients with COVID-19 in the NHS, typically in large numbers. The experience amassed across the cadre, combined with physician referrals and clinical questions from DPHC, front-line commands and occupational medicine (OM), made it clear that clinical and occupational assurance of SP returning to work after COVID-19 illness would require a fully integrated clinical approach. A plan was developed in May 2020 by Defence physicians, and embraced by DPHC general practitioners, for diagnosis and clinical assurance of patients post-COVID-19 based on cardio-pulmonary assessment. This proposal was positively received in June 2020 by OM and by Defence Rehabilitation specialists at DMRC. The collaborative effort between the four clinical cadres gave rise to the clinical delivery of the DMRC COVID-19 Recovery Service (DCRS). The pathway began assessment of patients in August 2020.

BACKGROUND
COVID-19 infection causes a spectrum of clinical disease from mild, self-limited illness to a severe pneumonitis with multi-organ involvement, including disseminated thrombotic disease. Long-term effects have been seen in previous coronavirus outbreaks, with early evidence suggesting this is likely to be the case for COVID-19.23,4 More morbidity needs to be actively looked for and managed. Even in its mildest form, SARS can cause a persistent reduction in exercise capacity at 12 months.5 Emerging literature suggests that post-COVID-19 syndrome is a multisystem disorder with pulmonary, cardiac and neurological pathology contributing to the ongoing burden of disease.

Following SARS, the health status of survivors was significantly worse compared with the healthy population.1 In particular, patients demonstrated residual respiratory problems, even in asymptomatic individuals, with pulmonary function testing (PFT) showing a mild or moderate restrictive pattern, consistent with muscle weakness, in 6%–20% of subjects.7 Furthermore, 62% had pulmonary fibrosis detected on high-resolution CT (HRCT) 1–2 months postdischarge.8 Data from two case series of SARS in children indicate a full clinical recovery without perceptible reduction in exercise tolerance; however, up to 34% of cases demonstrated changes on HRCT, and up to 10% had changes in PFT at 5–6 months of follow-up.9 10 Similar findings are being reported in COVID-19 survivors. In a cohort of patients in China, 14% had abnormal forced expiratory volume in 1 s and 9% had an abnormal forced vital capacity at the time of hospital discharge.11 Additionally, evidence is emerging that COVID-19...
predisposes to the development of pulmonary thromboembolic disease. CT pulmonary angiography (CTPA) acquired in 106 patients suspected of, or proven to have, COVID-19 identified pulmonary embolus in 32 patients (30%).

As well as pulmonary complications, COVID-19 is associated with cardiac complications, as were SARS and Middle East respiratory syndrome (MERS). In particular, there is an association with arrhythmias and myocardial injury, which occur in 20%–30% of infections and contribute to around 40% of COVID-19 deaths. Troponin levels appear to reflect severe systemic inflammation and, in common with interleukin-6, serum ferritin and C reactive protein, are a marker of disease progression and poor prognosis. The aetiology of cardiac complications is likely multifactorial, including direct myocardial injury, elevated systemic inflammatory burden, ACE2-receptor downregulation, hypoxia, hypotension and drug toxicity.

Early reports from Wuhan, China, also point to a significant burden of neurological disease following COVID-19 infection. Some 36% of patients manifest at least one symptom, with complaints ranging from mild (anosmia and dysgeusia) to severe (encephalitis and stroke). In specialised neuroscience centres dealing with the most severely affected patients, encephalopathy was present in 10/43 of cases, nervous system inflammation (e.g. encephalitis or myelitis) in 12/43 cases and stroke in 8/43 cases. Interestingly, >50% of patients who had a stroke have concomitant microhaemorrhages, while the number of cases of acute disseminated encephalomyelitis reported in 1 month of the pandemic equalled that normally seen in a 5-month period in the UK. Guillain–Barré syndrome and its variants have also been reported. It is likely that direct neuronal injury, inflammation, hypercoagulability and the effects of systemic illness each contribute to the neuropathology of COVID-19.

While most patients experience a time-limited neurological syndrome, COVID-19 infection could have long-term neurological effects. Analysis of data pooled from studies of SARS, MERS and COVID-19 suggests that a small proportion of patients experience confusion, memory impairment, chronic fatigue and mood disturbance for months or even years following infection.

Similar issues are experienced by survivors of para/infectious and inflammatory encephalitis. Given the impact of these outcomes on a SP’s fitness to return to work, their early identification and management is paramount.

In view of the potential impact for significant long-term adverse effects of COVID-19, careful clinical assessment is required to identify, diagnose and manage symptoms, in order to guide a safe, sustainable return to work. The DCRS fulfils this requirement. SPs who may have sustained significant pathology from COVID-19 are identified on the basis of the severity of acute illness; high-risk clinical features; prolonged recovery time or evidence of physiological limitation after recovery from the acute infection (Box 1).

To assist this process, the Defence Consultant Advisor in Medicine and Defence Advisor in General Practice, working with Defence Consultant Advisor in Occupational Medicine and Defence Consultant Advisor in Rehabilitation, directed the development of medical policy detailing clear guidance to military clinicians and commanders on the clinical and occupational management of SP post-COVID-19. This guidance is published, as two schematics, in Annexes A and B of JSP 950, Leaflet 002 COVID-19 Supplementary Policy (Figures 1 and 2).

**DCRS PATHWAY**

Clinical risk stratification, which necessarily begins in primary care, is supported by an ECG and both resting and postexercise peripheral oxygen saturations for those who exceed a defined threshold of symptom severity (Figures 1 and 2). In this way, the use of objective cardiopulmonary measures as part of clinical assessment, which underpins the DCRS, begins in primary care.

SP who are referred from primary care into the DCRS pathway undergo a second tier of functional and cardiopulmonary assessment at DMRC with spirometry, 6 minute walk test, cardiopulmonary exercise testing (CPET), 12-lead ECG, thoracic echocardiogram (TTE) and a series of standardised questionnaires to assess mental health, fatigue, quality of life and cognitive function. These investigations are possible due to the rapid expansion of diagnostic capability at DMRC specifically for the DCRS to include TTE and clinical CPET.

This diagnostic output informs clinical review by DSHC and DMRC physicians in a jointly run clinic and determines the appropriate secondary care investigations. These take place the following day, during an outpatient attendance in the NHS (Oxford University Hospitals NHS Foundation Trust). Secondary care investigations, where indicated, include gas transfer, arterial blood gas measurement, CT chest, dual-energy CTPA (Figure 3), exercise echocardiogram and cardiac MRI. The joint clinic at DMRC also assesses potential neurocognitive deficits in all patients. Significant abnormalities trigger a clinical referral to a service neurologist, with appropriate brain imaging as required.

In the week following the DCRS attendance at DMRC Stanford Hall, the results of all the secondary care investigations are reviewed in a second multi-disciplinary team meeting (third tier). This meeting provides a diagnosis, clinical management plan (including rehabilitation), as well as occupational disposal recommendations to the patient’s unit medical officer (MO) and chain of command (CoC). The details of the clinical patient pathway are shown in Figures 4 and 5.

In order to gain an appreciation of the occupational and operational impact on Defence of the initial SARS-CoV-2 infection, an observational study (Military COVID-19 Observational Outcomes in a Viral Infectious Disease (M-COVID)) has been approved by the MOD Research Ethics Committee (1061/MODREC/20). The study will follow-up volunteers from the DCRS pathway to further assess their cardiopulmonary and functional outcomes. Study endpoints include all of the clinical pathway investigations supplemented by additional research measures, including interval lung function testing and CPET at 12 months; experimental laser gas analysis of expired breath to characterise ventilation–perfusion matching in the lung; magnetic resonance spectroscopy of the heart to determine effects on cardiac metabolism; and brain MRI to uncover central nervous system pathology.

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**Box 1** Categories of service personnel (SP) requiring Defence Medical Rehabilitation Centre COVID-19 Recovery Service (DCRS) referral

- SP who require the DCRS will have one of the following:
  1. Hospital admission.
  2. Significant adverse medical findings (e.g. chest imaging changes or troponin rise).
  3. Prolonged symptoms in recovery (8 weeks or more).
  4. Significant physical limitation (e.g. severe breathlessness or exercise desaturation).
CONCLUSION
COVID-19 is a new disease. Although there is emerging evidence to suggest that there is significant pulmonary, cardiac and neurocognitive morbidity from SARS-CoV-2 infection, we do not yet know the extent or the severity of this morbidity. Furthermore, most of the existing research effort is directed at civilian patients suffering from severe acute infection. This civilian population is older and has a greater burden of comorbidities (eg, type 2 diabetes, morbid obesity and chronic severe lung disease) than is seen in military personnel, necessitating a specific analysis of COVID-19 effects on SP. The output of the clinical DCRS pathway, allied to the M-COVID observational study, is essential not only to understand individual patient pathology and occupational restrictions but also to provide medical intelligence.

Figure 1  Post-COVID-19 actions and considerations for return to duty/training.23 CoC, chain of command; DCRS, Defence Medical Rehabilitation Centre COVID-19 Recovery Service; SP, service personnel; DMICP, Defence Medical Information Capability Programme; PT, Physical Training; PTI, Physical Training Instructor; MTF, Medical Treatment Facility.

Figure 2  Post-COVID-19 DMICP assessment tool.22 DCRS, Defence Medical Rehabilitation Centre COVID-19 Recovery Service; DMRC, Defence Medical Rehabilitation Centre; DPHC, Defence Primary Healthcare; DMICP, Defence Medical Information Capability Programme.
to inform Defence about the impact of COVID-19 on operational capability. Understanding of long-term outcomes may also inform subsequent risk assessment, health behaviours and public health measures.

An agile response to rehabilitation was mirrored by early insight from DSHC physicians regarding the importance of identifying those patients at high risk of COVID-19 morbidity. This idea was immediately supported, adopted and developed, in a collegiate approach guided by the senior clinical advisors of four cadres. The result is an integrated clinical and occupational pathway beginning in primary care, with input from medicine, Defence Rehabilitation and OM, creating an output intended to provide the most detailed, accurate and appropriate advice to the SP’s MO and CoC. This whole service, from approved clinical concept to delivery of DCRS, aligned to a prospective cohort study, with academic, ethical and commercial approval, was delivered in under 3 months.

The development of the DCRS demonstrates the agility and effectiveness of clinical response to a novel challenge within Defence. Indeed, elements of the tier 3 investigations have already influenced and driven changes to NHS care pathways, demonstrating the ability of the Defence

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**Figure 3** Dual-energy Computed Tomography pulmonary angiogram images.

**Figure 4** Flowchart of DCRS. CoC, chain of command; DCRS, Defence Medical Rehabilitation Centre COVID-19 Recovery Service; DMRC, Defence Medical Rehabilitation Centre; DPHC, Defence Primary Healthcare; OUH, Oxford University Hospital; MDT, Multi-disciplinary team meeting.
Medical Services (DMS) to catalyse developments in healthcare. In the DMS, there is a much closer relationship and more developed common purpose than is the case in larger, more fragmented healthcare settings. This relationship affords the opportunity to address a clinical problem with due consideration of the whole clinical care pathway from the point of infection in the community, through specialist clinical assessments and investigations, back to primary care. The patient-centred DCRS integrates the needs and opinions of all clinical cadres. It delivers a diagnosis, clinical management plan and specific occupational recommendation in order to support the rapid return to health and productive employment of all SPs affected by COVID-19.

Contributors DAH, EN and RB conceived the idea of Defence Medical Rehabilitation Centre COVID-19 Recovery Service, which was developed in a group by DAH, EN, RB, LH, ANN and ANB. The pathway was delivered after intellectual and practical contributions from DAH, EN, ANB, RB-D, OO, RC, ES, DI, ANB and RP. The manuscript was drafted by OOS and DAH and critically reviewed by all authors.

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REFERENCES

1 Ministry of Defence. Number of COVID-19 tests in defence and positive cases in the UK armed forces.


Figure 5  Schematic of DCRS clinical investigations. CMR, cardiovascular MRI scan; CPET, cardiopulmonary exercise test; DCRS, Defence Medical Rehabilitation Centre COVID-19 Recovery Service; DE CTPA, dual-energy CT pulmonary angiogram; DMRC, Defence Medical Rehabilitation Centre; MDT, Multi-disciplinary team meeting.
Personal view


