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- Continuous Positive Airway Pressure Adherence and Response to Cognitive Processing Therapy for Veterans Living with Post-traumatic Stress Disorder and Obstructive Sleep Apnea
- When and How Military Students' Self-Esteem May Become an Obstacle in Seeking Professional Mental Health Help When Needed?
- Musculoskeletal Injury and Physical Fitness Across U.S. Army Occupational Specialties

The Journal of the Australasian Military Medicine Association

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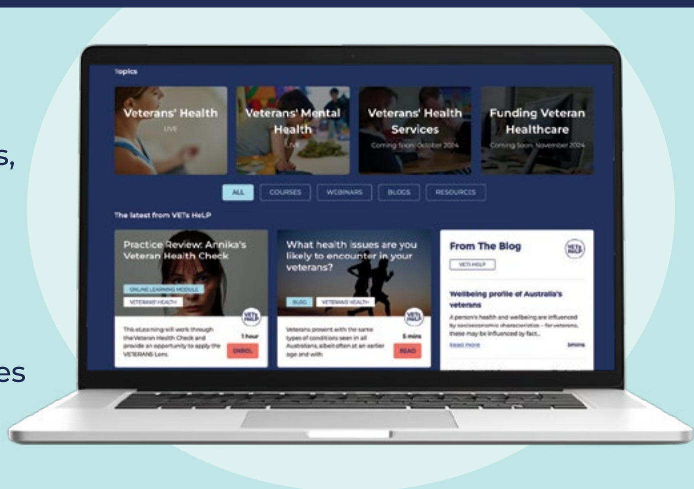

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Table of Contents

Editorial

Original Articles

History

Review Articles

Short Communication

Commentary

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STATEMENT OF OBJECTIVES

The Australasian Military Medicine Association is an independent, professional scientific organisation of health professionals with the objectives of:

- Promoting the study of military medicine
- Bringing together those with an interest in military medicine
- Disseminating knowledge of military medicine
- Publishing and distributing a journal in military medicine
- Promoting research in military medicine

Membership of the Association is open to doctors, dentists, nurses, pharmacists, paramedics and anyone with a professional interest in any of the disciplines of military medicine. The Association is totally independent of the Australian Defence Force.

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Editorial

Misinformation and Disinformation

In my Editorial in January 2023, I discussed the role of deception in war and peace.[1] While deception is accepted military strategy, such as in Operation Bertram in the lead up to the second Battle of El Alamein in October 1942, attempts to intentionally or non-intentionally deceive in medicine have the potential to cause great harm to public health.[2] In 2023, focus was on anti-vaccine claims directed at the COVID-19 messenger RNA vaccines.[3] While these claims have continued, they have now extended to other vaccines, with significant falls in childhood vaccination rates in Australia. This has contributed to the resurgence of measles and other vaccine preventable diseases in Australia and other parts of the world, and the inevitable serious disease and, on rare occasions, deaths. This misinformation and disinformation is 'deeply rooted in anything but scientific knowledge and reasoning'[3], and highlights the ongoing importance of both establishing the evidence-base and actively addressing misinformation and disinformation that is being promulgated. Through the Journal, we should be both striving to enhance that evidence base and addressing the increasing false information.

Our second issue of 2025 contains a range of articles on diverse topics spanning physical training, operational healthcare, naval medical history, infectious disease, mental health, and veterans' health. We continue to attract a good range of articles, including from overseas, as is demonstrated in this issue. Other military and veterans' health articles, however, are always very welcome, and we would encourage all our readers to consider writing on their areas of military or veterans' health interest. We would particularly welcome papers based on presentations given at the Brisbane 2024 ICMM conference or planned for our 2025 conference, but welcome any articles across the broader spectrum of military health.

Dr Andy Robertson, CSC, PSM
Commodore, RAN
Editor-in-Chief

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Continuous Positive Airway Pressure Adherence and Response to Cognitive Processing Therapy for Veterans Living with Post-traumatic Stress Disorder and Obstructive Sleep Apnea

K Kunes, C Johnson, A Kohli, D Driscoll, R Walters, S Ramaswamy

Abstract

Introduction: Cognitive processing therapy (CPT) is a first-line psychotherapy for veterans with post-traumatic stress disorder (PTSD). Comorbid obstructive sleep apnoea (OSA) poses challenges to treatment with continuous positive airway pressure (CPAP) associated with improved PTSD symptoms. CPAP adherence, particularly in those with PTSD, remains a concern. This study explored whether CPAP adherence was associated with CPT efficacy in United States veterans with comorbid PTSD and OSA.

Materials and methods: From September 2015 through July 2020, 25 veterans received CPT for their PTSD and were also issued a CPAP machine to treat their OSA. Outcomes included PTSD and depression symptoms measured by the PCL-5 and PHQ-9, respectively. Following guidance from the Centers for Medicare and Medicaid Services, CPAP adherence was defined as ≥4 hours of wear time at night on ≥70% of days between CPT sessions. Linear mixed-effects models were estimated to evaluate whether change in PTSD and/or depression symptoms was moderated by CPAP adherence.

Results: Veterans received a median of 12 CPT sessions (range: 4–13) across a median of 77 days of follow-up (range: 7–549). PCL-5 and PHQ-9 scores improved significantly (both $p < 0.001$), with benefit observed at day 125 and day 50, respectively. However, these improvements were not moderated by CPAP adherence (interaction $p = 0.668$ and 0.124 for PTSD and depression symptoms, respectively). CPAP use, the apnea-hypopnea index (AHI), and mask leak also did not moderate symptom improvement.

Conclusions: Despite that OSA has been suggested to reduce PTSD treatment efficacy, our study demonstrated both PTSD and depression symptom improvement irrespective of CPAP adherence. Although the small sample size and retrospective design require additional research, the overall improvement in PTSD symptoms, regardless of CPAP adherence, supports continued use of CPT by mental health practitioners for veterans with comorbid PTSD and OSA.

Keywords: post-traumatic stress disorder, cognitive processing therapy, obstructive sleep apnoea, continuous positive airway pressure, sleep disorders

Introduction

Post-traumatic stress disorder (PTSD) is a debilitating disorder that affects up to 30% of United States veterans in their lifetime.[1-4] Cognitive processing therapy (CPT) is a recommended first-line treatment for veterans with PTSD,[5] utilising evidence-based psychotherapy techniques to reduce negative thoughts about oneself and the world, and challenge unhelpful beliefs.[6] CPT is widely utilised in the United States Department of Veterans Affairs (VA) for the treatment of PTSD, with cumulative prevalence rates of up to 19.9% recorded between 2001 and 2014.[7] The therapeutic process entails a repetitive and detailed exploration of traumatic memories, requiring participants to invest considerable cognitive effort and emotional involvement. Furthermore, the therapy typically extends across multiple sessions, underscoring its comprehensive and time-intensive characteristics, demanding significant resources from both therapists and clients.[8]

Sleep disturbance, particularly insomnia and recurrent nightmares, is considered one of the most prominent features of PTSD. Additionally, veterans with PTSD face an elevated risk for sleep disorders such as obstructive sleep apnoea (OSA),[9] involving repetitive blockage of the airway leading to fragmented sleep and decreased oxygen flow to the brain. Evidence suggests that OSA can exacerbate symptoms of PTSD, and conversely, PTSD may negatively impact symptoms of OSA.[10-11] Although the exact reasons for these associations are not entirely clear, the observed higher rates of OSA risk and/or diagnosis in veterans with PTSD may arise from the interconnected effects of chronic stress, combat-related sleep disruptions and the physiological and psychological consequences of PTSD.[9] Established OSA risk factors include advanced age, male sex, obesity and high blood pressure,[12] but there is increasing evidence challenging the applicability of classic OSA risk factors, especially body mass index (BMI) and age, to young veterans with PTSD. Two recent studies on younger veterans (mean age = 33.4–35.1 years) with lower BMI (BMI = 19.08–28.9) found high rates of OSA risk (63.7–69.2%), suggesting that the relationship between PTSD and OSA may not be fully explained by traditional risk factors within the veteran population.[9,13]

The significant utilisation of CPT for treating PTSD, coupled with its resource-intensive nature, necessitates an examination of factors influencing its effectiveness. Consequently, it is crucial to pinpoint potential health factors that might affect the efficacy of this treatment approach. Recent evidence suggests OSA is a contributing factor to the reduced effectiveness of CPT for the treatment of PTSD in veterans, as disrupted sleep can adversely impact various aspects of cognitive functioning and learning.[14] Continuous positive airway pressure (CPAP) is a primary treatment for OSA that can be effective in increasing restful sleep and oxygenation, as well as reducing daytime sleepiness and nightmares in patients with PTSD. Several studies have reported that CPAP use is associated with improvement in PTSD symptoms.[15-19] However, patient adherence to CPAP therapy is often low, particularly among those with comorbid PTSD, which can result in the worsening of both PTSD and OSA symptoms.[11,20-21] Thus, improving CPAP adherence becomes a valuable target for enhancing the efficacy of CPT. This retrospective chart review focuses on veterans receiving CPT for PTSD, with the additional consideration of comorbid OSA. This study aimed to investigate whether adherence to CPAP is associated with lower PTSD and depression symptoms in veterans receiving CPT. Results could provide valuable insight into optimising the effectiveness of CPT in individuals with comorbid PTSD and OSA.

Methods

Data source and veteran sample

We identified veterans treated between September 2015 through July 2020. Veterans included were diagnosed with PTSD using the criteria defined within the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), had received at least one session of CPT for PTSD, and were diagnosed with OSA via polysomnography. Further, Veterans were included if they were at least 19 years of age and were issued a CPAP machine for their OSA.

Outcomes

The primary outcome included PTSD symptoms measured via the PTSD Checklist for DSM-5 (PCL-5), with a secondary outcome of depression symptoms measured via the Patient Health Questionnaire-9 (PHQ-9). The PCL-5 is a 20-item self-report measure that assesses the 20 DSM-5 symptoms of PTSD with a total symptom severity score ranging from 0 to 80 obtained by summing the scores for each of the 20 items.[22] The PHQ-9 is a 9-item self-report measure based on DSM-5 criteria for major depressive disorder used to assess depression severity with a total score ranging from 0 to 27.[23] For both outcomes, higher total scores indicate worse symptom severity. Because this study was primarily focused on response to CPT in veterans with PTSD, the PHQ-9 was not always administered at each CPT session. CPT sessions were ideally delivered weekly for 12 consecutive weeks, but this was unrealistic for many veterans as sessions are time consuming (60–90 minutes) and frequently rescheduled. Additionally, veterans may have forgotten or could not complete the practice assignments requiring sessions to be repeated.

Covariates

Daily CPAP data included mean daily CPAP use, mean residual apnea-hypopnea index (AHI), and mean mask leak. We defined CPAP adherence as ≥4 hours of wear time at night on ≥70% of days between

CPT sessions.[24-25] We also collected demographic variables that included age, biological sex, race, marital status and BMI.

Statistical analysis

Descriptive statistics are presented as median and interquartile range or count and per cent. Linear mixed-effects models were estimated for PCL-5 and PHQ-9 to account for the repeated outcome measurements from the same veteran. The proportion of outcome variability between veterans was initially quantified via intraclass correlation; we tested heterogeneous veteran-specific residual variances for both outcomes. Time from initiation of CPT to PCL-5 and/or PHQ-9 measurement was quantified in days, with day 0 set at the intake session. For repeatedly measured (e.g., time-varying) covariates of CPAP adherence, daily CPAP wear time, AHI and mask leak, veteran-specific covariate means were included in the model alongside the time-varying covariate to statistically control for veteran-level mean differences across the repeated measurement of the occasion-level covariate (i.e., some veterans averaged higher covariate values across measurements compared to other veterans).[26] The functional form for all continuous covariates was estimated using restricted cubic splines with knot points at the 5th, 35th, 65th and 95th percentiles; nonlinear forms were retained as indicated by the likelihood ratio test. Two-way day-by-CPAP covariate interaction effects were estimated to evaluate whether changes in PCL-5 and/or PHQ-9 scores differed by CPAP covariates. All analyses were conducted using SAS vs 9.4 with two-tailed $p < 0.05$, indicating statistical significance.

Results

Veteran characteristics

We identified 25 veterans during the study period who received CPT for PTSD with access to a CPAP machine for OSA. Veterans had a median of 12 CPT sessions (IQR: 8–12; range: 4–13). Median age was 43 years (IQR: 35–50; range: 26–69), 22 (88%) were male, 24 (96%) were White, the median BMI was 35.6 (IQR: 32.2–41.2; range: 26.7–64.0), and 19 (79%) reported being in a relationship.

PTSD symptoms

During the study period, a total of 261 PCL-5 observations were provided with a median of 11 PCL-5 observations per veteran (IQR: 7–13; range: 2–23) across a median of 125 total days of follow-up (IQR: 83–174; range: 35–549). Approximately 49.7% of the variability in PCL-5 scores was due to veteran-specific differences. Further, differential variability in PCL-5 scores was observed between veterans (–2 log likelihood difference = 2067, df = 24, $p < 0.001$) that was accounted for by allowing each veteran to have their own estimated residual variance. At the intake session, the average PCL-5 score was 42 (95% CI: 36–49). We observed statistically significant nonlinear change in PCL-5 scores in the days following the intake session ($p < 0.001$; Figure 1), with improvement in PCL-5 scores beginning around day 125 after intake.

Concurrent CPAP data were available for 182 (69.7%) of the 261 PCL-5 observations; mask leak data were available for only 127 (48.7%) observations. Table 1 provides descriptive statistics across PCL-5 observations by individual CPAP or OSA covariate. Veterans were adherent to their CPAP use on 48.3% of occasions. After controlling for the proportion of time during which the veteran was adherent with their CPAP, change in PCL-5 scores across the study period did not differ by whether the veteran was adherent with their CPAP between CPT sessions or not (interaction $p = 0.668$; Figure 2). In addition, statistically similar changes in PCL-5 scores across the study period were observed by CPAP use (interaction $p = 0.433$), mean residual AHI (interaction $p = 0.401$), and mean mask leak (interaction $p = 0.924$).

Depression symptoms

During the study period, a total of 130 PHQ-9 observations were provided with a median of 3 PHQ-9 observations per veteran (IQR: 2–11; range: 1–23) across a median of 107 total days of follow-up (IQR: 80–174; range: 7–549). Approximately 39.3% of the variability in PHQ-9 scores was due to veteran-specific differences; a model allowing differential between-veteran variance across observations would not estimate. At the intake session, the average PHQ-9 score was 14 (95% CI: 11–16). We observed statistically significant nonlinear change in PHQ-9 scores in the days following the intake session ($p = 0.021$; Figure 3), with improvement in PHQ-9 scores beginning around day 50 after intake.

Concurrent CPAP data were available for 98 (75.4%) of the 130 PHQ-9 observations; mask leak data were available for only 72 (55.4%) observations. Table 1 provides descriptive statistics across PHQ-9 observations by individual CPAP or OSA covariates. Veterans were adherent to their CPAP use on 54.1% of occasions. After controlling for the proportion of time during which the veteran was adherent with their CPAP, change in PHQ-9 scores across the study period did not differ by whether

Table 1. Descriptive statistics for CPAP covariates stratified by outcome

Covariate	PCL-5 observations (n = 182)	PHQ-9 observations (n = 130)
Adherent		
No	94 (51.7)	45 (45.9)
Yes	88 (48.3)	53 (54.1)
Overall usage		
No	55 (30.2)	26 (26.5)
Yes	127 (69.8)	72 (73.5)
Hours per day	5.8 [2.4–7.6]	5.7 [4.0–7.0]
AHI	2.4 [1.5–4.0]	2.5 [1.9–4.1]
Large mask leak		
No	31 (24.4)	15 (20.8)
Yes	96 (75.6)	57 (79.2)
Minutes per day	3.5 [0.9–27.1]	6.9 [1.0–40.2]

Note. Descriptive statistics presented as median [IQR] or n (%). 'Adherent' defined as CPAP use ≥4 hours per night on 70% of days between CPT sessions.

the veteran was adherent with their CPAP between CPT sessions or not (interaction p = 0.124; Figure 4). In addition, statistically similar changes in PHQ-9 scores across the study period were observed by CPAP use (interaction p = 0.447), mean residual AHI (interaction p = 0.768), and mean mask leak (interaction p = 0.881).

Discussion

We hypothesised that CPAP adherence would be associated with better clinical response to CPT; however, we found that PTSD symptoms improved significantly throughout CPT regardless of CPAP adherence. Similarly, depression symptoms showed significant improvement in both veterans who were CPAP adherent or nonadherent. Further, average hours of CPAP use, residual AHI and mask leak were also not associated with a differential change in PTSD or depression symptoms. Although we did not find statistically significant associations, our study responded to a call to address an important gap in the literature specific to CPT and OSA treatment.[14] This is important because, to our knowledge, this is the first study to specifically evaluate CPAP adherence and clinical response to CPT.

There is strong evidence that comorbid OSA increases PTSD symptom severity, as several studies have suggested that CPAP use may play a role in PTSD symptom reduction.[11,15,18] Lettieri et al. established that CPAP adherence improved daytime somnolence and quality of life in those with comorbid OSA and PTSD but did not evaluate PTSD symptoms.[11] Tamanna et al. found that CPAP adherence reduced nightmares but did not measure overall PTSD symptoms.[15] Orr et al. found that the percentage of nights CPAP was used (to any degree) was associated with improvements in PTSD symptoms, but only modestly so.[18] None of these investigations evaluated patients undergoing psychotherapies, so our study extends these findings by evaluating the relationship between CPAP adherence and PTSD symptoms throughout psychotherapy.

The efficacy of CPT in PTSD is well established; however, the impact of CPAP adherence on psychotherapy outcomes is relatively unknown.[27-28] Mesa et al. found that those with OSA benefited from CPT but to a lesser degree than those without OSA with a secondary finding that those who had 'presumed access' to CPAP reported modestly lower PTSD symptoms after CPT than those without CPAP access.[14] Inadequate access to CPAP introduces the confounding factor of the 'healthy user effect' where individuals with higher utilisation of services (i.e., those that had taken the initiative to seek out and obtain a CPAP device) may be more likely to benefit from non-study interventions such as general health maintenance, pharmacotherapy and social assistance programs. Our study differs in that all veterans had sought out CPAP devices, reducing the 'healthy user' effect, and therefore, we were more able to assess the effect of CPAP adherence on symptom modification.

In addition, we found that PHQ-9 scores began to show improvement around day 50 after the initial CPT session. Clinical experience suggests that mild depression symptoms respond faster to psychotherapies than PTSD, and this was the case in our study as PCL scores only started improving at day 125, over 4 months after the intake. This delay in response to CPT might be explained by logistical issues such as scheduling, provider availability, missed appointments and avoidance tendencies that accompany PTSD. Ideally, CPT sessions should be provided at weekly intervals for 12 weeks. A national survey of providers within VA PTSD clinical teams who deliver CPT found significant variability in session frequency with appointments with an average of 3 weeks between sessions.[29] Further, it is not uncommon for well-studied CPT protocols used in randomised control trials to fail in translation to clinical practice for various practical reasons such as cancellations of appointments, medical illness, clinic capacity and demand, etc. We did not collect data related to these confounding factors, which could explain the therapeutic lag in PTSD symptoms relative to depression symptoms. Furthermore, the end of our study period overlapped with the COVID-19 pandemic, which likely resulted in significant barriers to CPT session frequency and consistency as clinicians resorted to telehealth.

Our study has limitations inherent to small, retrospective cohort studies, including small sample size, information bias and a limited ability to collect and control confounding factors. We also did not collect data on other sleep and psychiatric conditions, so our results may not represent a population with pure PTSD; it is possible comorbid disorders could have altered CPT response. Further, we could not access polysomnography-derived AHI scores (pre-CPAP use); thus, the AHIs reported in our study are reflective only of residual AHI in those utilising CPAP. As such, the severity of OSA in our sample of veterans could not be determined. This prevented us from evaluating differential CPT benefits by OSA severity. Finally, the veterans in our sample had mild PTSD at baseline and were overwhelmingly male and white. Therefore, our findings could have limited external validity for those with moderate or severe PTSD, female veterans or non-white patient populations. When considered together, our results are best viewed as hypothesis-generating and future research should include a larger sample size with more diverse patients.

Conclusion

Our results suggest that veterans benefit from CPT regardless of CPAP adherence. As such, mental health practitioners should not be discouraged or dissuaded from utilising CPT for veterans who are not adherent to CPAP. However, we recommend that practitioners routinely assess and educate veterans to be compliant with their CPAP, given the adverse health effects of OSA.

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EDUCATIONAL WORKSHOP SERIES

DATE	LOCATION	TOPIC	SPEAKERS
21 March	Brisbane City	Tropical Medicine	A/Prof Richard Bradbury, JCU & Dr G Dennis Shanks, ADF MIDI
21 June	Sydney City	Calm After Combat: healing and mental peace post-service	BRIG Nicole Sadler
26 July	Melbourne City	Calm After Combat: healing and mental peace post-service	BRIG Nicole Sadler
16 August	Brisbane City	Massive Haemorrhage Protocols	CDRE Anthony Holley
30 August	Sydney City	Massive Haemorrhage Protocols	CDRE Anthony Holley
13 September	Melbourne City	Skin Deep: The 10 most common dermatological complaints in a military setting	LTCOL Dr Keng-Ee Thai

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When and How Military Students' Self-Esteem May Become an Obstacle in Seeking Professional Mental Health Help When Needed?

V I Karamanoli

Introduction

The present study aims to investigate how self-esteem and perceptions of self or public stigma may influence a) the attitudes towards seeking professional mental health help in the military environment and b) the intentions to seek professional mental health help. The military is associated with duties of high risks, which often cause exposure to traumatic stimuli.[1] Those duties are associated with mental health problems,[2] affecting individual's occupational functioning and organisation's performance. Although military personnel are at high risk of mental health problems, they do not prefer to seek mental health help due to stigmatising beliefs and fears common among military personnel.[3-4]

Stigma is the perception that a flaw makes the person unacceptable socially because of psychological or physical characteristics.[5] Both self-stigma and public stigma may be related to attitudes or intentions of seeking psychological support, both among civilians and military personnel.[6-7] Self-stigma—the perception that an individual's value diminishes when seeking help from a professional of mental health—relates to seeking psychological help,[6-8] and is associated with an individual's self-esteem and the reconstruction of self-value and personal perception as being socially unacceptable. In addition, self-stigma is associated with social representations of mental illness and psychological support. Social representations of mental illness could reduce an individual's personal self-image, self-esteem and self-efficacy.[6-8] Usually, military personnel form a self-image of power and capacity, and therefore, experiences of symptoms of mental health disorders are perceived as a sign of weakness and are accompanied by shame.[7] Public stigma, associated with seeking psychological help, is the perception that the person who seeks psychological support is undesirable or socially unacceptable.[6-7] This perception can lead to stereotypes, prejudice and social discrimination against people seeking professional psychological support.[6-7]

Several studies have analysed the social representation of seeking psychological support in the military. Results indicate that the central core of the social representation for seeking support consists of two categories: a) positive evaluation of psychological support services; and b) results for all three categories of participants: soldiers, military students and officers.[8-9] In the same study, stigma appears in the dynamic zone of the representation, which is a common category but less powerful for all three categories of participants. This finding might indicate that stigma is of considerable concern to military personnel.[10] The positive evaluation of psychological support services and their effects can be interpreted as recognition of the value of psychological support within the army. At the same time, this finding is in line with another that mediates the correlation between fear of stigma and attitude towards the process.[11]

According to research, an individual for whom there is information that looks for support and care for depression is considered emotionally unstable, less interesting and less confident than the person who seeks help for back pain.[12] Mental health stigma[13] appears to be one of the most frequently reported barriers to mental health help-seeking in the military environment.[14] Often, seeking psychological support is experienced as inferior or unsuitable,[15] so avoidance is inevitable.[16-17] Fear of stigmatisation is the most common reason that people avoid seeking mental health help. This fear can be more powerful if people consider how others would react if they knew about their behaviour of help-seeking.[18] Corrigan states that people who avoid care from mental health specialists do so to avoid being classified as mentally ill. He also adds that their secondary benefit is to avoid feeling bad about themselves.[6]

Among other factors, stigma appears to be a central factor due to which military personnel frequently delay disclosing mental health issues and illnesses.[19] Military personnel have the belief that others in the military will build a negative impression and stigmatise people who seek professional mental health help. Obstacles can arise for their promotion and career because of this choice, preventing them from going on future deployments.[20]

Recent research has shown that the military has more positive attitudes about the causes of mental illness but more negative attitudes about the job rights of those with mental illness,[21] and that cultural issues interfere with the process of seeking help, the highest scores in the comprehensive stigma perception index appeared for schizophrenia and substance use, and the lowest for anxiety disorders and anorexia.[22] In addition, a significant finding is that military personnel may experience even greater public stigma than civilians because their military records are less private because mental health professionals are often employed by the military, and seeking mental health help or enjoying the care of mental health specialists may harm possible job options and promotions.[23] Military officials do not seek psychological help even when needed because they believe a) they will be considered weak, b) their superiors will react differently towards them than the rest of the personnel, and c) their colleagues in their unit will trust them less.

Corrigan and his colleagues state that self-stigma affects feelings of self-esteem and self-efficacy, and for that reason, anticipated self-stigma may lead people to avoid seeking help.[24] Research has shown that anticipated self-stigma and perceived public stigma have a differential impact on attitudes towards formal and informal help-seeking. The internalisation of negative stereotypes concerning the process of seeking mental help was negatively correlated to the perceived importance of medical providers' services (general practitioners and psychiatrists).[25] Another study in a civilian sample indicated that although both gender and the self-stigma associated with psychological help-seeking predicted attitudes toward seeking psychological help significantly, public stigma was not a significant predictor of help-seeking attitudes.[26-30]

Military personnel, according to research, believe that seeking mental help would have devastating effects on their military career.[27] In contrast, 45% of military personnel believe that military colleagues will avoid anyone seeking professional help.[28] Military self-stigma was found to mediate the relationship between military identity components and suicide risk.[28] A recent study has shown that there is no evidence of an association between self-stigma and gender, age, sexual trauma or military trauma. In contrast, self-stigma was associated with lower income and higher levels of anxiety, depression and traumatic stress symptoms.[29]

On the other hand, beliefs in the effectiveness of mental health treatment are positively associated with seeking help.[30] The negative effect of the belief that visiting the Psychological Support Office might be a sign of weakness and the doubt about the role of the psychologist and the observance of confidentiality disappears when there is a perception of its usefulness. This means that the recognition of psychological support's usefulness in the army mediates the correlation between fear of stigma and attitude towards the process of seeking mental help.[11]

Research questions included the following:

a. We assume that the intention of seeking mental help will be negatively correlated with the perception of self or public stigma coming from this attitude in the military environment (H1).
b. We assume that a negative attitude towards mental health services will be negatively correlated with the intention of seeking professional help, even if it is needed. Also, we hypothesise that a negative attitude towards psychological support may be positively correlated with the perception of self and public stigma coming from this procedure (H2).
c. We assume that the intention of seeking mental help will be negatively correlated with the attitude towards professional help in the military environment (H3).
d. We assume that self-esteem will be positively correlated with a positive attitude towards mental health services and negatively with the perception of self and public stigma coming from the procedure of seeking mental health help (H4).
e. We hypothesise that high military self-esteem might encourage the belief that military personnel can handle by his own the psychological difficulties and might strengthen a) negative attitudes towards the psychological support in the military, b) beliefs of self-stigma, and c) beliefs of public stigma that might lead to low intentions of seeking professional mental health help (H5).

Method

The research was conducted in military schools in Greece and has received relevant permission from the Greek military authorities, both for the conduct and presentation of the results. This is an anonymous survey in which students of the military academies participated voluntarily. After declaring their consent to participate in the survey, students completed the questionnaires (in print form) in academic education, in the presence of the researcher and without receiving any help or pressure. The researcher collected and stored the data while all data security requirements were met.

Measures

The survey used measured a) attitudes toward help-seeking, b) intention of seeking professional help, c) self-stigma, d) public stigma, and e) self-esteem. The scales used are the following:

a) Attitudes Toward Seeking Professional Psychological Help Scale-Short Form[15] (Cronbach's alpha.85). This scale consists of 10 items rated on a 4-point bipolar Likert scale, as follows: 0 = Disagree 1 = Partly disagree; 2 = Partly agree; 3 = Agree. The scale assesses individual attitudes toward seeking professional psychological help. Here are some examples of the items: *(1) If I believed I was having a mental breakdown, my first inclination would be to get professional attention.*

   Items were reversed according to the instructions of the constructors of the scale (e.g. 'The idea of talking about problems with a psychologist strikes me as a poor way to get rid of emotional conflicts'). Fischer and Farina reported that the shorter scale was equivalent to the longer 29-item scale (correlation of 0.87), had good internal consistency reliability (*Cronbach's alpha* = 0.84), and test-retest reliability (r = 0.80) over a 4-week interval[15]. The present study found good internal reliability for Attitudes Toward Seeking Professional Psychological Help Scale-Short Form (*Cronbach's alpha 0.85*).

b) General Help-Seeking Questionnaire (GHSQ)[31] (*Cronbach's alpha 0.75*). Participants completed the GHSQ. Evaluations of this scale were made on a 7-point scale (1 = Extremely unlikely, 7 = Extremely likely). This scale uses the following standard problem probe, within which targeted problem types can be interchanged: 'If you were having a personal or emotional problem, how likely is it that you would seek help from the following people?': *(4). mental health specialist.* Wilson and his colleagues reported that the GHSQ items had good internal consistency reliability (*Cronbach's alpha* = 0.85–0.92, test-retest reliability assessed over three weeks)[31]. In the present study, we found good internal reliability for General Help-Seeking Questionnaire (GHSQ) (*Cronbach's alpha 0.75*).

c) Measuring the self-stigma associated with seeking psychological help with the Self-Stigma of Seeking Help (SSOSH) scale[32]) (*Cronbach's alpha 0.83*). Participants completed the 10-item SSOSH scale,[32] which asked them to rate each item on a scale ranging from 1 (not at all) to 5 (extremely well) on the degree to which it assessed the concept. The items were like the following: *(1) I would feel inadequate if I went to a therapist for psychological help.* The items were reversed following the author's instructions (e.g. *(2) My self-confidence would NOT be threatened if I sought professional help, (7) I would feel okay about myself if I made the choice to seek professional help*). Several studies cross-validated the reliability of the scale (*Cronbach's alpha = 0.86 to 0.90*; test-retest, 0.72). In the present study, we found good internal reliability for SSOSH scale (*Cronbach's alpha 0.83*).

d) Perceptions of stigmatisation by others for seeking psychological help (PSOSH) scale[18] (*Cronbach's alpha 0.82*). The 5-item PSOSH was administered to the participants with these instructions: 'Imagine you had an academic or vocational issue that you could not solve on your own. If you sought counselling services for this issue, to what degree do you believe that the people you interact with would?' (e.g. *(4) Think of you in a less favourable way.* Responses to the above items are according to a 5-point Likert scale, as follows: *1: Not at all; 2: A little; 3: Some; 4: A lot; 5: A great deal.* Items are summed so that higher scores reflect greater perceptions of stigma by those close to the person seeking psychological help. (*Cronbach's alpha = 0.84–0.85* through test-retest reliability assessed over three weeks). In the present study, we found good internal reliability of PSOSH scale (*Cronbach's alpha 0.82*).

e) Self-Esteem Scale (SES)[33] (*Cronbach's alpha 0.75*). Participants completed the Self-Esteem Scale, a ten-item Likert scale with items answered on a 4-point scale, from 4 strongly agree to 1 strongly disagree. (e.g., *(3) I think that I have a number of good qualities).* Five items were reversed according to the instructions (e.g. *(2) At times, I think I am no good at all*). In the present study, we found good internal reliability of the SES (*Cronbach's alpha 0.75*).

All scales were administered to participants in Greek after being translated twice by different persons and then combined. The items in Greek were given for back translation to a third person to see if there was anything misunderstood. The relevant handling test was carried out to determine whether the questionnaires work for Greece's military personnel. The self-esteem questionnaire has been validated for the Greek population,[34] as well as the questionnaires for public and self-stigma.[35]

Participants

Students (N=442) from Hellenic Academies from all three armed forces participated in this research anonymously and voluntarily. Sociodemographic characteristics are presented in Table 2. Most of the participants (50,7%) were students of Evelpidon Hellenic Military Academy (N=224), (30,8%) were students of Hellenic Naval Academy (N=136) and finally, 81 of them were students of Hellenic Air Force Academy (18,3%). As expected, due to the ratio of admission to military schools, the majority of participants were men (70,4%, N=311), and only 47 were women (10,6%). In comparison, a notable percentage of 19% did not mention their gender at all (N=84). At the same time, there seems to be an equal distribution of students per year of study, 1st (N=91 20.6%), 2nd (N=106 19.7%), 3rd (N=87 24.2), 4rth (N=76 17.2), Missing Value (N=82 21.1).

Results

Cronbach's alpha of all the scales used was very good, from 0.75 up to 0.85, as is clearly presented in Table 1. There is no statistically significant interdisciplinary or transgender differentiation to a) the attitude towards the institution of psychological support, b) the intention of seeking psychological support in an emergency, and c) the beliefs about the results of self and public stigma concerning that process.

Descriptive statistics

Results indicated that only a small percentage of the military personnel would seek help from a) a mental help specialist for all three forces, b) telephone consult, or c) a doctor. Even if there were suicidal ideas, attitudes and intentions to seek professional help didn't change significantly. In addition, attitudes toward seeking professional psychological help tend to orient themselves towards the negative pole. Students seem to and present as admirable people who solve their problems independently.

Table 1. Cronbach's alphas for all questionnaires

	N	Items	*Cronbach's alpha*
Attitudes Toward Seeking Professional Psychological Help Scale-Short Form	442	10	0.85
General Help-Seeking Questionnaire (GHSQ)	442	10	0.75
Self-Stigma of Seeking Help (SSOSH)	442	10	0.83
Perceptions of stigmatisation by others for seeking psychological help (PSOSH)	442	5	0.82
Self-Esteem Scale (SE)	442	10	0.75

Table 2. Sociodemographic characteristics of the participants

Baseline Characteristic	n	%
Hellenic Military Academy	224	50.7
Naval Academy	136	30.8
Air Force Academy	81	19
Gender		
Male	311	70.4 Men
Female	47	10.6
Missing value	84	19
Year of study		
1st	91	20.6
2nd	106	19.7
3rd	87	24.2
4th	76	17.2
Missing value	82	21.1

Table 3. Descriptive statistics

	N	Mean	Median	SD
1. Attitudes	442	1.69	1.8	1.14
2. Self-stigma	442	2.99	2.9	1.91
3. Public stigma	442	2.05	1.8	1.17
4. Self-esteem	442	3.88	3.01	1.81

As shown in Table 3, a) attitudes towards seeking mental help have a mean of 1.60 (SD 1.14), b) the mean of self-stigma is 2.99 (SD1.91), c) the mean of public stigma is 2.05 (SD 1.17), and d) the mean of self-esteem is 3.88 (SD 1.81).

Correlation

Furthermore, a Pearson correlation coefficient was computed to assess the linear relationship between attitudes towards seeking mental help and perceptions of self-stigma and public stigma. There was a negative correlation between attitudes and self-stigma, $r = -0.515$, $p < 0.001$, and attitudes and public stigma, $r = -0.214$, $p < 0.001$ (Table 4), which means that as the sense of self-stigma decreases, attitudes towards seeking help become more positive, and vice versa, as the sense of self-stigma increases, the attitudes to seek professional help become more negative. In addition, self-stigma is positively correlated to public stigma ($r = -0.341$, $p < 0.001$, which means that as the sense of self-stigma increases, so does the sense of public stigma and vice versa.

Moreover, self-esteem is positively correlated to attitudes concerning seeking mental help ($r = -0.177$, $p < 0.001$), to public stigma ($r = 0.127$, $p < 0.001$) and to the intention of seeking mental help $r = .175$, $p < .001$, which means that as the sense of self-esteem increases, attitudes towards seeking mental help become more positive, and vice versa, as the sense of self-esteem decreases, attitudes become more negative. Moreover, when self-esteem increases, public stigma increases as well, as does the intention of seeking mental help. We found that self-esteem is neither positively nor negatively correlated with self-stigma, despite the theory of self-stigma for the general population, according to which beliefs of low self-esteem related to self-stigma concerning seeking psychological support (Table 1). We should investigate this finding further, especially in the military environment and the structure of military personnel's self-esteem.

In line with the relevant literature, positive attitudes towards seeking mental help are positively correlated to the intention of visiting the Office of Mental Help ($r = 0.365$, $p < 0.001$, and even more so when there are suicidal ideas ($r = 0.365$, $p < 0.001$ (Figure 1)

Table 4. Correlation of attitudes towards seeking professional mental help with self-stigma, public stigma and self-esteem

Variable	1	2	3	4
1. Attitudes	-			
2. Self-stigma	-0.515**	-		
3. Public stigma	-0.214**	0.341**	-	
4. Self-esteem	0.177**	-0.003	0.127**	-

** Correlation is significant at the 0.01 level (2 tailed).

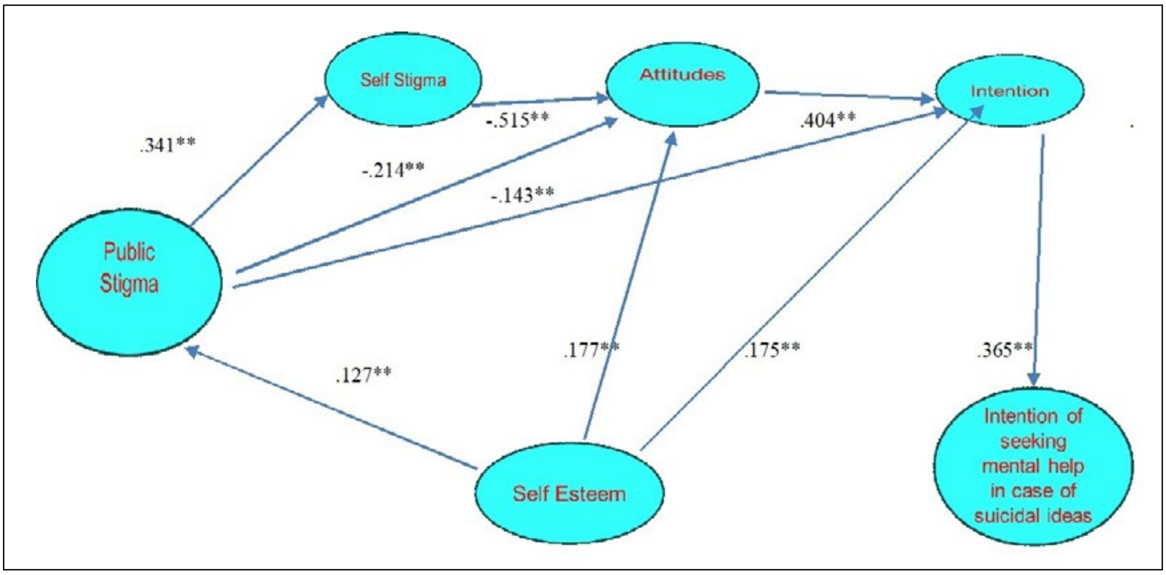

Figure 1. Association of public stigma with attitudes towards seeking psychological help, self-stigma, intention to seek mental help, intention to seek mental help in case of suicidal ideas and self-esteem.

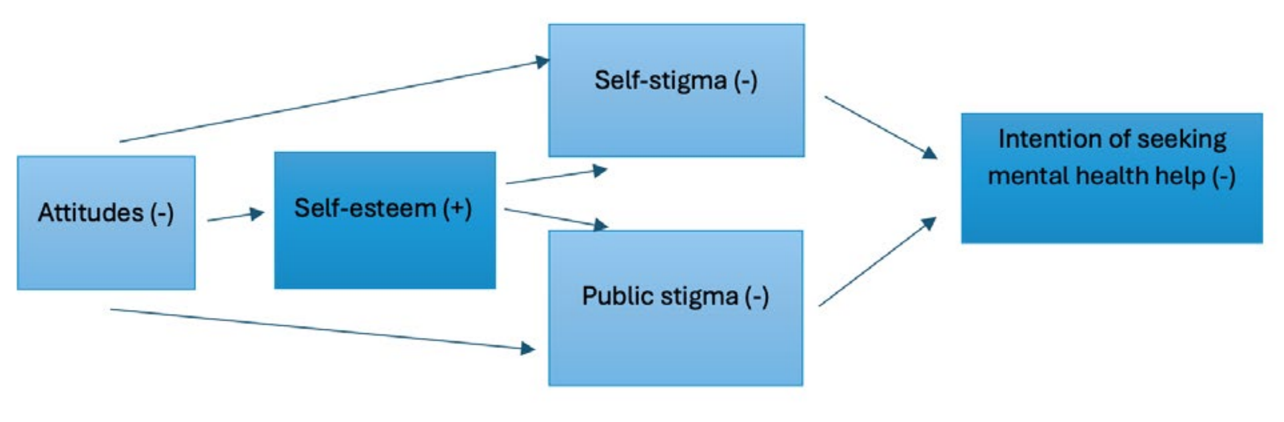

Figure 2. The case of mediation. High self-esteem mediates attitudes, self-stigma and public stigma and diminishes the intention of seeking professional mental help.

Regression analysis

In the case of mediation, high military self-esteem, which reinforces the belief that a military person is capable of doing it on his own, even if there are positive attitudes towards the institution of psychological support in the military, reinforces beliefs of self-stigmatisation and public stigma, and reduces the intention to seek help from a mental health professional. Perceptions of self-esteem are positively related to attitudes towards seeking mental health help (β=0.19). However, negatively related to self-stigmatising beliefs (β=-0.46), and public stigmatisation beliefs about seeking psychological help in case of need (β=-0.25), as clearly presented in Figure 2 and Table 5.

Discussion

Findings did not reveal any difference between the sexes or the students of all three armed forces regarding the attitudes towards and the intention to seek mental help or perceptions of self and public stigma concerning this process. Results, in line with other research, showing that stigmatising attitudes are prevalent and associated with a reluctance to seek help,[36] confirm our hypothesis that self and public stigma are negatively correlated and intentions of seeking professional mental help (H1), (H2), (H3) and positive correlated with the attitudes towards seeking mental help (H4), in line with the theory that social attitudes do not predict behaviours.[37]

The value that comes from the results is the importance of self-esteem variable. Self-esteem seems to be a more independent characteristic among military personnel. It has a different structure and dynamic not affected by stigma (H4), perhaps because of the military education and the emphasis on power and qualities. Although a lot of research and theory supports stigmatised group members' tendency to have low global self-esteem, empirical research typically does not support this prediction sometimes in civilians,[38] and in the present study among military personnel. Regression analysis has shown that self-esteem mediates beliefs of self and public stigma, as well as attitudes towards seeking professional help when needed. In line with research that highlights the difficulty of knowledgeable individuals who have high self-esteem,[39] to change attitudes, it seems that military personnel who build a social identity of strength, high self-confidence and high self-esteem, characteristics that help them build the social identity of the worthy soldier, find it challenging to seek psychological help in difficult times as this would amount to a decline in military virtues. The implications of this result must be examined with new research addressing both civilian and military samples to identify similarities and differences in beliefs, stereotypes, attitudes, intentions and personality characteristics. In the military, stressful conditions trigger the mental vulnerability of individuals, and in combination with the access to weaponry, the need for psychological support is more than necessary.

The role of the family and the social environment should be further examined in supporting military personnel to adjust to stressful conditions. The unit commanders should be trained to encourage military personnel not to avoid psychological help if necessary. Psychoeducation should enrich beliefs and attitudes concerning the protection of privacy, not only concerning the content of the sessions but even concerning the attendance of a mental health specialist. Commanders are responsible for protecting the potential of every military officer to seek mental help, if necessary, without being afraid of being stigmatised and unwanted. It must be clear that only mental health specialists can diagnose and take effective care of a psychological problem. Experienced

Table 5. Regression analyses of variables in intention to seek help from a mental health professional

	B	F	df	sig	R^2
Attitudes	0.19	19.322	1.168	0.001	0.27
Self-stigma	-0.46	-45.761	1.168	0.001	0.21
Public stigma	-0.25	-11.912	1.168	0.001	0.06
Self-esteem	0.52	64.444	1.68	0.001	0.27

military personnel can detect behavioural disorders and cooperate with mental health specialists to deal with behavioural problems.[23] In addition, subsequent research should check whether the military status of military psychologists negatively mediates the seeking of help from mental health specialists in the military and reinforces the fear of public stigma.

As with all research, there are limitations to this study. First, there was no provision to limit the research to a sample of military personnel experiencing more intense psychological stress or personality disorder. However, we did take a random sample from all military personnel. This poses an additional limitation as if someone does not experience a problem, he/she will not have a positive attitude toward seeking help, especially when there is a risk of public stigma. On the other hand, we had no information about their experience adjusting to the military environment. Perhaps some interviews should bring interesting information about the social and emotional atmosphere. Second, it is true that we haven't included the health personnel in the participants because health personnel are very small in the military school. Students go to military hospitals if needed. That is a minor limitation to our work because this could numerically balance the number of male and female participants and perhaps affect the statistical analysis. Unfortunately, the staff are a small group of less than 10, who couldn't have influenced the statistics. Third, our participants were only military students, which limited our work since our results couldn't be generated for all military personnel. Perhaps future research should include military officers who train military students to compare attitudes and behaviours among military groups.

In summary, the present research focused on the factors that influence the search for mental help in the military, with emphasis on military trainees and found that high morale and high self-esteem, cultivated in the military as qualifications and guarantees for individual and national security, create additional obstacles to the process of seeking psychological help as beliefs of self-stigmatisation and public stigma undermine it.

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Musculoskeletal Injury and Physical Fitness Across U.S. Army Occupational Specialties

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Abstract

Background: Military occupations are widely diverse, requiring specific skill sets and physical demand levels to accomplish their objectives.

Purpose: To describe musculoskeletal injury and physical fitness across US Army military occupational specialties (MOS).

Methods: Demographics, health behaviours and physical training data were obtained by electronic survey. Musculoskeletal injuries and Army Combat Fitness Test (ACFT) data were obtained from Department of Defense medical and training systems. A multivariable logistic regression model was performed to assess the role of injury risk and MOS while controlling for known military injury risk factors.

Results: Participants were 2124 male and 433 female enlisted US Army Soldiers. Injury incidence by MOS ranged from 29% to 62% for males and 49% to 71% for females. MOS contributed to injury risk for males, with the exception of Support and Administration. All other MOSs had between 2.0 to 5.3 times greater injury risk than Field and Air Defense. Military Police had a 3.8 times higher injury risk for females compared to Military Intelligence. Considering physical fitness, ACFT performance by MOS ranged from 425 to 491 points for males and 310 to 364 points for females (maximum score of 600 points). Males in Infantry and females in Military Police MOSs had the highest ACFT scores of 491 and 364 points, respectively. In addition, health behaviours and physical training varied by MOS.

Conclusion: Surveillance of injury incidence and physical fitness, along with health behaviours and physical training by MOS, may be used to focus injury prevention strategies.

Introduction

The US Army consists of a wide array of military occupational specialties (MOS) and is one of the largest providers of training and vocational education in the world.[1] Each MOS has a unique job description, estimated physical demand level and specific skills to successfully accomplish the mission.[2] Overall, there are approximately 203 career management fields grouping related MOSs for enlisted US Army Soldiers.[2]

Physically demanding professions, such as the military, have been shown to have high risks of injury.[3,4] Risk factors for injury can be classified as intrinsic and extrinsic.[5] Some intrinsic risk factors associated with injury are female sex, older age, low aerobic fitness, low and high body mass index (BMI), tobacco use and sleep duration.[5,6] Some extrinsic risk factors associated with injury are running distance, foot marching and job duties.[5] These are all known risk factors for injury and have been established in the literature.[5,7-9] In previous investigations of the US Army, soldiers with high physical demand MOSs were at a higher risk of injury, hospitalisation and disability.[3,4] However, specific MOSs identified as having a higher injury risk or disability are limited in the literature. Amoroso et al. showed that male Infantry Soldiers and female light-wheeled vehicle mechanics had the highest rate of musculoskeletal hospitalisations.[10] Anderson et al. indicated that the MOS groups of chemical, explosives and ammunition, and armour had a higher risk of injury compared to Infantry Soldiers.[11] However, contrary to other investigations, Anderson et al. indicated no significant differences in injury risk between MOS physical demand levels when controlling for age, BMI, cigarette use and physical fitness.[11] Lincoln et al. showed that soldiers in electronic equipment repair and other technical occupations were at a higher risk for overall disability.[4] Based on the previous literature, no consensus shows any specific MOS as having higher injury risk compared to other MOSs. In addition, physical demand levels of these MOSs did not seem to predict injury risk consistently. Understanding the relationship between MOS and injury risk is essential in reducing US Army healthcare burden costs.[12] Physical fitness assessments for job selection, placement and retention are often requirements of physically demanding occupations.[13] In the military, physical fitness is critical to performing required occupational tasks.[13] To the authors' knowledge, Anderson et al. is the only study that has investigated physical fitness by MOS. In this study, MOS groups with the highest muscular endurance were Infantry, Field and Air Defense Artillery, and Engineer groups.[11] MOS groups with the highest aerobic endurance were Infantry and Armor groups.[11] Specific physical fitness attributes could impact occupational task performance, ultimately providing a protective effect against injuries among US Army Soldiers.[14,15]

Though the relationship between musculoskeletal injury risk and physical fitness in the US Army has been well established,[8] there are limited studies assessing the relationships between US Army MOS, musculoskeletal injury risk and physical fitness.[11] This investigation aimed to describe musculoskeletal injury and physical fitness across MOS groups.

Methods

Participants. Participants were enlisted Active-Duty US Army Soldiers representing multiple MOSs who completed a survey during Army Combat Fitness Test (ACFT) field testing. A report summarising the results of the ACFT field testing can be found elsewhere.[16] The US Army Public Health Center (APHC) Public Health Review Board (PHRB) reviewed and approved this investigation as public health practice (PHRB#18-688). Informed consent was obtained from all respondents prior to participation.

Survey. A survey was electronically sent from January 2020 to April 2020 to 28 452 soldiers in 61 US Army battalions field testing the ACFT. Thirty of these US Army battalions were augmented by medical and fitness teams consisting of a physical therapist, two strength and conditioning coaches, an athletic trainer, a dietitian, an occupational therapist (in 8 of the 30 battalions) and a mental health specialist (in 4 of the 30 battalions). The survey obtained the following information from each Soldier: demographics, MOS, health behaviours, physical training activities and injuries. US Army policy was referenced to categorise individual MOSs into 13 MOS groups (Table 1).[2] Occupational Physical Assessment Test (OPAT) physical demand categories of moderate (frequently or constantly lift up to 40 pounds), significant (frequently or constantly lift 41 to 99 pounds) and heavy (frequent or constantly lift 41 to 100+pounds) were used to identify the workload requirements of each specific MOS (Table 2).[2,17] The OPAT performance standards are described in detail elsewhere.[18] Personal physical training time was limited to soldiers reporting 20–840 minutes per week, respectively. This exclusion criteria was used to omit responses that indicated more or less than credible amounts of exercise.[19] MOS groups with 10 or fewer participants were considered not sufficiently representative and were excluded from demographic and logistic regression analysis (Tables 3–6).

Physical performance. ACFT data were obtained from the Digital Training Management System (DTMS). DTMS is a US Army web-based training management tool that captures and stores training data, such as ACFT performance and body composition data. At the time of this investigation, minimum US Army physical fitness standards, as measured by the ACFT, were established using the OPAT physical demand categories of moderate, significant and heavy.[17] In addition, ACFT standards were age and gender-neutral during the entire data collection period. The ACFT consisted of six events in the following order: a three-repetition maximum deadlift using a hex bar, a standing power throw for distance, the maximum number of hand release push-ups in two minutes, a sprint-drag-carry event for time, maximum number of leg tucks in two minutes and a two-mile run for time. As of October 1, 2019, the ACFT event and scoring standards were re-evaluated and slightly changed from the previous standards, as displayed in Table 2. The preliminary ACFT standards (July 31, 2018, to September 30, 2019) will be referred to as the initial field testing (IFT) minimum event passing standards. ACFT re-evaluated minimum passing standards (October 1, 2019, to June 11, 2020) will be referred to as initial operational capability (IOC) minimum passing standards. ACFT minimum event passing standards were based on MOS. IFT and IOC ACFT event passing standards are listed in Table 2. The scoring scale for each event ranges from 0 (lowest performance) to 100 (highest performance) points. The minimum points needed to pass the moderate, significant, and heavy categories are 60, 65 and 70 points for each event, respectively. Therefore, the total minimum passing score for the moderate, significant, and heavy physical demand categories were 360, 390 and 420 points, respectively. The maximum score was 600 points.

Medically treated injuries. The Armed Forces Health Surveillance Division provided Defense Medical Surveillance System data for all outpatient and hospitalisation medical encounters in the 12 months prior to survey administration. The Taxonomy of Injuries was subsequently used to identify musculoskeletal injury-related International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) diagnosis codes to create a musculoskeletal injury index consisting of both overuse and traumatic musculoskeletal injuries.[20]

Statistical analysis. The Statistical Package for Social Sciences (SPSS), Version 28.0 (IBM Corp., Armonk, NY, USA) was used for all statistical analyses. Data were stratified by sex due to physiological differences influencing injury risk.[21] Continuous variables were divided into quartiles or specified categories. To allow for comparisons across MOS groups, frequencies, means and standard deviations (SD) by MOS group were presented for demographics, health behaviours, physical training, soldiers augmented with a medical and fitness team, physical demand category, injury characteristics and physical fitness as measured by performance on individual ACFT events and ACFT total score. Medical encounter data was used to report injured body areas and to conduct logistic regression modelling. Injury activity data was incomplete in the medical records, therefore, descriptive statistics on self-reported injury activity data from surveys were reported.

Cumulative injury incidence by MOS group was calculated as the number of soldiers with one or more

Table 1. Self-Reported Military Occupational Specialty Group

Military Occupational Specialty Group	Male % (n)	Female % (n)	Total % (n)	Military Occupational Specialty (MOS)
Engineers	18.9 (402)	10.6 (46)	17.5 (448)	12A, 12B, 12C, 12H, 12K, 12M, 12N, 12R, 12T, 12W, 12X, 12Z
Repairer and Maintenance	18.7 (398)	7.6 (33)	16.9 (431)	15B, 15D, 15F, 15G, 15H, 15K, 15L, 15M, 15N, 15P, 15Q, 15R, 15T, 15U, 15W, 15Y, 15Z, 91A, 91B, 91C, 91D, 91E, 91F, 91H, 91J, 91L, 91M, 91P, 91S, 91X, 91Z, 94D, 94E, 94F, 94H, 94S, 94W, 94Y
Supply and Logistics	11.4 (243)	23.8 (103)	13.5 (346)	77W, 92A, 92F, 92G, 92L, 92M, 92R, 92S, 92W, 92Y, 92Z
Field and Air Defense Artillery	8.0 (169)	2.3 (10)	7.0 (179)	13F, 13J, 13M, 13Z, 14E, 14G, 14H, 14T, 14Z
Medical	5.7 (121)	13.2 (57)	7.0 (178)	68A, 68B, 68C, 68D, 68E, 68F, 68G, 68H, 68J, 68K, 68L, 68M, 68P, 68Q, 68S, 68V, 68W, 68X, 68Y, 68Z
Military Intelligence and Electronic Warfare	5.6 (120)	9.5 (41)	6.3 (161)	17E, 35F, 35G, 35L, 35M, 35N, 35P, 35S, 35T, 35X, 35Y, 35Z
Signals and Communications	6.4 (136)	4.8 (21)	6.1 (157)	25B, 25C, 25L, 25N, 25P, 25Q, 25S, 25T, 25U, 25W
Transportation	5.9 (125)	6.0 (26)	5.9 (151)	88H, 88M, 88N, 88Z
Military Police	4.9 (105)	6.7 (29)	5.2 (134)	31B, 31E, 31K, 31Z
Chemical Warfare, Explosives and Ammunition	4.1 (87)	8.1 (35)	4.8 (122)	74D, 89A, 89B, 89D
Infantry	5.2 (110)	0.2 (1)	4.3 (111)	11B, 11C, 11M, 11Z
Support and Administration	2.0 (43)	6.7 (29)	2.8 (72)	27D, 36B, 38B, 42A, 42R, 56M, 79R, 79S
Armor	3.1 (65)	0.5 (2)	2.6 (67)	19D, 19K, 19Z
Total	100 (2124)	100 (433)	100 (2557)	139 individual MOSs

musculoskeletal injuries in the 12 months prior to survey administration, divided by the total number of soldiers surveyed. Body area and activity injury variables were calculated as the number of injuries divided by the total number of injuries. A one-way ANOVA and a one way ANOVA with Tukey post hoc tests were used to evaluate statistically significant differences for continuous variables. Chi-square and Chi-square pairwise comparisons with a Bonferroni correction were used to evaluate statistically significant frequency differences. Univariable logistic regression was used to identify associations of MOS, demographics, health behaviours, physical training, physical demand level and physical fitness with musculoskeletal injury risk. A Chi-square was used to identify trends. Variables selected for a multivariable model were known risk factors (e.g., BMI and physical fitness) and additional variables of interest from the univariable model. These variables were entered into a multivariable logistic regression model to assess the association of injury risk with MOS. Odds ratios (OR) and 95% confidence intervals (95% CI) were reported. Results were considered statistically significant at $p \leq 0.05$.

Results

A total of 2124 male (27.9±7.2 years and 26.7±3.5 kg/m^2) and 433 female (26.9±6.8 years and 24.8±2.9 kg/m^2) Soldiers completed the electronic survey. The majority of males (52%) and females (52%) were of lower rank (E1-E4). Twelve-month cumulative

Table 2. Army Combat Fitness Test: minimum passing standards by physical demand level

Physical demand level	Male % (n)	Female % (n)	Total % (n)	IFT ACFT Minimum passing standards	IOC ACFT Minimum passing standards	Military Occupational Specialty (MOS)
Moderate	57 (1208)	52 (225)	56 (1433)	DL 140 lbs SPT 4.6 m HRPU 10 rep SDC 3:35 min LTK 1 rep 2MR 21:07 min	DL 140 lbs SPT 4.5 m HRPU 10 rep SDC 3:00 min LTK 1 rep 2MR 21:00 min	11M, 11Z, 12A, 12H, 12K, 12N, 12R, 12T, 12W, 12X, 12Z, 13J, 13M, 13Z, 14E, 14G, 14H, 14T, 14Z, 15G, 15H, 15K, 15L, 15M, 15P, 15Q, 15Z, 17E,19Z, 25B, 25C, 25N,25P, 25Q, 25S, 25T,25U, 25W, 27D, 31E, 31Z, 35F, 35G, 35L, 35M, 35N, 35P, 35S,35T, 35X, 35Y, 35Z,36B, 38B, 56M, 68A, 68B, 68C, 68D, 68E,68F, 68G, 68H, 68J,68K, 68L, 68M, 68P, 68Q, 68S, 68V, 68X, 68Y, 68Z, 74D, 77W, 79R, 79S, 88Z, 89A,89B, 89D, 91A, 91B, 91C, 91D, 91E, 91F,91H, 91J, 91L, 91M,91P, 91S, 91X, 91Z,92L, 92Y, 92Z, 94D,94E, 94F, 94H, 94S, 94W, 94Y
Significant	22 (467)	34 (147)	24 (614)	DL 160 lbs SPT 6.5 m HRPU 20 rep SDC 2:45 min LTK 3 rep 2MR 19:00 min	DL 180 lbs SPT 6.5 m HRPU 20 rep SDC 2:30 min LTK 3 rep 2MR 19:00 min	12M, 15B, 15D, 15F, 15N, 15R, 15T, 15U, 15W, 25L, 31B, 31K, 42A, 42R, 68W, 88N, 92A, 92F, 92G, 92R,92S, 92W
Heavy	21 (449)	14 (61)	20 (510)	DL 180 lbs SPT 8.5 m HRPU 30 rep SDC 2:09 min LTK 5 rep 2MR 18:00 min	DL 200 lbs SPT 8.0 m HRPU 30 rep SDC 2:10 min LTK 5 rep 2MR 18:00 min	11B, 11C, 12B, 12C,13F, 15Y, 19D, 19K, 88H, 88M, 92M
Total	100 (2124)	100 (433)	100 (2557)			139 individual MOSs

Note: IFT (initial field testing) ACFT and IOC (initial operational capability) ACFT standards were age and gender-neutral. IFT ACFT and IOC ACFT minimum score (point range from 0-100) by physical demand category: Moderate = 60 points per event, Significant = 65 points per event, and Heavy = 70 points per event. DL, 3-Repetition Maximum Deadlift; SPT, Standing Power Throw; HRPU, Hand Release Push-Ups; SDC, Sprint, Drag and Carry; LT, Leg Tuck; 2MR, Two-Mile Run; lbs, pounds; m, metres; rep, repetitions; min, minutes.

Table 3. Demographics, health behaviours, physical training, physical demand level, injury and physical fitness data by Military Occupational Specialty for male respondents

	Overall	Field and Air Defense Artillery	Support and Admin	Signals and Comms	Military Intelligence and Electronic Warfare	Armor	Engineers
Age, BMI, Health behaviours, Physical training and per cent of Soldiers augmented with a battalion medical and fitness team							
n range	1333-2124	106-169	24-42	103-136	82-120	39-65	211-402
Age	27.9±7.2	26.5±6.6	30.4±9.5	28.1±6.8	29.3±7.6	25.7±7.7	25.6±5.8
BMI	26.7±3.5	26.3±3.5	27.1±3.6	26.7±3.5	26.8±3.5	25.8±3.5	26.0±3.3
Sleep (hours/wk)	5.9±1.4	5.8±1.5	5.8±1.3	5.9±1.2	6.0±1.0	6.1±1.6	5.9±1.4
% Smoker	18	26	12	18	14	26	18
Weight training (min/wk)c	96±127	116±160	55±67	109±134	127±133	69±86	84±105
Running (miles/wk)c	7.0±6.8	7.2±7.5	6.2±4.6	7.3±7.1	5.7±4.8	8.1±5.8	7.4±8.4
Foot marching (miles/mth)	5.0±7.9	5.3±6.4	3.9±8.7	3.8±6.6	3.2±5.1	2.6±7.3	6.4±10.1
% Soldiers with a medical and fitness team	81	98	44	24	95	95	99
Physical demand level							
% Heavy	21.1	4.7	0	0	0	92.3	39.3
% Significant	22.0	0	55.8	5.1	0	0	4.0
% Moderate	56.9	95.3	44.2	94.9	100	7.7	56.7
Injury (medical record and self-reported)							
% MR Injury	46	29	35	41	43	45	45
Top three medical record injured body areas							
% Knee	20.3	20.4	13.3	14.3	19.6	24.1	20.6
% Lower Back	18.9	10.2	40.0	19.6	13.7	10.3	20.6
% Ankle	10.5	10.2	13.3	7.1	7.8	10.3	11.7
Top three self-reported injury activities							
% Running	31	24	37	41	32	47	29
% Weight training	18	29	21	16	26	13	14
% Occupational	8	0	0	2	13	0	12
Army Combat Fitness Test							
n range	1426-1569	122-140	27-31	105-116	85-101	38-39	304-327
DL (lbs)	241±58	241±58	232±55	237±63	253±62	221±50	246±56
SPT (m)	9.3±1.7	9.3±1.7	8.9±1.6	9.1±1.9	9.2±2.1	8.7±1.6	9.3±1.7
HRPU (rep)	34.8±10.3	34.5±10.2	31.6±8.5	33.6±9.8	33.9±9.6	39.8±9.7	37.1±8.8
SDC (min)	1.90±0.26	1.89±0.28	1.99±0.25	1.91±0.28	1.90±0.29	1.87±0.18	1.91±0.23
LT (rep)	7.7±5.5	8.0±5.7	5.8±5.3	6.5±5.5	8.5±5.7	9.6±5.4	7.7±5.1
2MR (min)	17.1±2.2	17.0±2.0	17.3±2.2	17.2±1.9	16.9±1.7	17.2±2.2	16.8±2.1
Overall Score (pts)	456±70	458±67	425±91	440±87	454±77	468±49	461±65

Note: [a]ANOVA, [b]Chi-square and [c]Time or mileage ran during personal training, i.e., not unit training. Some survey questions were not answered; therefore, a range of soldiers in each MOS is reported. DL, 3-Repetition Maximum Deadlift; SPT, Standing Power Throw; HRPU, Hand Release Push-Ups; SDC, Sprint, Drag and Carry; LT, Leg Tuck; 2MR, Two-Mile Run; lbs, pounds, m, metres, rep, repetitions, min, minutes, wk, week; mth, month; pts, points.

Transportation	Military Police	Repairer and Maintenance	Infantry	Supply and Logistics	Medical	Chemical Warfare and Explosives Ammunition	p-value
85-125	68-105	258-398	69-110	162-243	71-121	55-87	
27.8±7.8	30.4±7.5	27.9±7.4	29.9±6.7	28.6±7.4	30.6±7.5	27.4±6.4	<0.01[a]
26.9±3.8	27.3±3.4	26.7±3.5	27.7±3.0	27.0±3.6	27.5±3.3	26.5±3.4	<0.01[a]
6.1±1.5	5.8±1.2	6.0±1.4	5.9±1.2	5.9±1.4	5.9±1.3	6.0±1.5	0.86[a]
18	17	22	18	9	17	16	<0.01[b]
57±97	117±138	85±126	140±151	72±108	140±142	93±122	<0.01[a]
7.7±8.3	5.7±5.2	6.3±5.8	6.9±7.1	7.3±6.3	8.4±7.3	7.6±7.2	0.16[a]
6.7±8.5	5.7±7.2	4.3±6.8	9.0±11.1	3.8±7.7	3.9±4.8	4.9±6.0	<0.01[a]
91	63	87	67	82	50	85	<0.01[b]
96.8	0	0.3	90	0.8	0	0	<0.01[b]
0.8	97.1	15.6	0	74.9	60.3	0	
2.4	2.9	84.2	10	24.3	39.7	100.0	
46	47	50	50	52	52	62	<0.01[b]
24.1	22.4	18.6	29.1	20.6	20.6	16.7	0.91[b]
19.0	28.6	18.1	12.7	18.3	23.8	20.4	0.25[b]
15.5	8.2	11.1	12.7	12.7	3.2	7.4	0.75[b]
36	23	33	33	44	16	22	0.03[b]
18	17	18	13	13	24	12	0.28[b]
6	14	7	17	3	9	16	0.03[b]
67-83	88-93	261-270	65-68	134-150	83-89	51-62	
244±54	246±53	230±58	277±56	227±57	249±61	239±69	<0.01[a]
9.5±1.7	9.5±1.5	9.2±1.6	9.9±1.5	9.3±1.9	9.8±1.6	9.4±2.0	0.01[a]
36.8±8.0	35.0±9.5	32.3±10.6	40.2±9.9	32.7±11.1	33.8±13.0	33.2±11.4	<0.01[a]
1.85±0.24	1.88±0.25	1.93±0.25	1.82±0.25	1.95±0.28	1.90±0.30	1.92±0.28	0.02[a]
7.8±5.2	7.6±5.3	6.9±5.1	10.3±5.2	7.5±5.7	7.9±6.0	8.2±6.4	<0.01[a]
17.2±1.9	17.0±1.9	17.5±2.4	16.5±2.1	17.2±2.5	17.5±3.0	16.6±2.1	0.02[a]
464±55	457±71	448±65	491±62	446±71	461±67	457±88	<0.01[a]

Table 4. Demographics, health behaviours, physical training, physical demand level, injury and physical fitness data by Military Occupational Specialty for female respondents

	Overall	Military Intelligence and Electronic Warfare	Support and Admin	Engineers	Transportation
Age, BMI, Health behaviours, Physical training and per cent of Soldiers augmented with a battalion medical and fitness team					
n range	231-420	27-41	21-29	23-46	12-26
Age	27.0±6.8	27.6±6.6	30.9±8.6	24.0±5.9	28.6±7.4
BMI	24.8±2.8	24.6±2.8	24.8±3.3	23.9±2.9	24.8±3.2
Sleep (hours/wk)	5.9±1.4	6.3±1.2	5.7±1.0	6.2±2.1	6.2±1.7
% Smoker	8	5	7	9	8
Weight training (min/wk)c	92±109	91±95	121±175	101±127	51±44
Running (miles/wk)c	5.7±7.9	3.7±3.5	6.6±6.2	5.3±4.4	5.4±5.8
Foot marching (miles/mth)	5.5±8.9	4.5±6.3	5.0±6.9	6.6±10.7	12.5±15.3
% Soldiers with a medical and fitness team	75	98	56	98	81
Physical demand level					
% Heavy	13.8	0	0	73.9	88.5
% Significant	35.0	0	65.5	4.3	7.7
% Moderate	51.2	100	34.5	21.7	3.8
Injury (medical record and self-reported)					
% MR Injury	60	49	52	54	58
Top three medical record injured body areas					
% Knee	19.9	10.0	20.0	40.0	20.0
% Lower Back	14.7	20.0	20.0	8.0	20.0
% Hip	14.3	15.0	13.3	4.0	6.7
Top three self-reported injury activities					
% Running	32	30	43	22	25
% Weight training	21	22	0	17	17
%Foot marching (w/load)	9	9	14	11	0
Army Combat Fitness Test					
n range	231-264	26-29	10	31-35	13-17
DL (lbs)	169±35	163±36	162±53	183±29	183±31
SPT (m)	5.8±1.7	5.5±1.3	6.5±1.5	5.8±1.4	6.0±1.3
HRPU (rep)	24.0±9.6	23.6±10.7	21.3±13.2	28.5±8.6	27.8±6.3
SDC (min)	2.50±0.39	2.48±0.45	2.51±0.49	2.45±0.38	2.38±0.40
LT (rep)	2.0±3.6	2.8±4.4	3.0±6.1	2.3±2.4	1.6±2.3
2MR (min)	18.7±2.0	18.1±1.8	18.7±2.4	18.7±1.8	18.2±1.8
Overall Score (pts)	332±81	336±91	353±92	349±76	328±92

Note: [a]ANOVA, [b]Chi-square and [c]Time or mileage ran during personal training, e.g., not unit training. Some survey questions were not answered; therefore, a range of soldiers in each MOS was reported. DL, 3-Repetition Maximum Deadlift; SPT, Standing Power Throw; HRPU, Hand Release Push-Ups; SDC, Sprint, Drag and Carry; LT, Leg Tuck; 2MR, Two-Mile Run; lbs, pounds; m, metres; rep, repetitions; min, minutes; wk, week; mth, month; pts, points.

Chemical Warfare and Explosives Ammunition	Medical	Military Police	Supply and Logistics	Repairer and Maintenance	Signals and Comms	p-value
15-35	32-57	16-29	52-103	20-33	13-21	
24.7±5.9	27.8±6.4	26.7±5.0	26.1±6.9	28.6±6.4	28.3±6.3	<0.01[a]
24.4±3.2	24.3±2.6	25.1±2.6	25.3±2.8	25.1±2.3	25.8±2.4	0.19[a]
5.9±1.5	5.9±1.2	5.7±1.5	5.8±1.3	5.8±1.4	5.7±1.4	0.18[a]
3	7	17	7	9	24	0.07[b]
105±90	109±120	94±101	74±96	67±79	87±99	0.08[a]
5.3±3.6	7.6±17.7	5.0±4.0	5.1±3.9	7.2±5.3	6.7±3.4	0.66[a]
5.6±10.6	6.3±9.4	6.4±8.4	4.2±8.0	3.7±4.3	2.4±2.8	0.02[a]
94	38	52	87	76	38	<0.01[b]
0	0	0	1.0	0	0	
0	45.6	96.6	64.1	9.1	4.8	<0.01[b]
100	54.4	3.4	35.0	90.9	95.2	
60	61	62	63	67	71	0.68[b]
19.0	17.1	22.2	18.5	18.2	13.3	0.50[b]
9.5	17.1	11.1	18.5	4.5	13.3	0.80[b]
23.8	8.6	16.7	13.8	22.7	26.7	0.48[b]
37	20	35	35	30	58	0.62[b]
32	27	18	28	17	8	0.36[b]
5	7	18	7	13	8	0.16[b]
19-25	30-33	18-24	47-55	20-21	14	
164±25	163±26	185±48	163±26	173±34	154±23	0.02[a]
5.6±1.9	5.7±2.3	6.5±1.7	5.7±2.3	5.5±1.4	5.9±1.4	0.60[a]
23.2±8.0	22.3±7.6	27.3±9.9	22.3±7.6	24.7±12.5	18.9±8.5	0.01[a]
2.62±0.27	2.53±0.38	2.46±0.61	2.53±0.38	2.45±0.32	2.49±0.35	0.83[a]
1.8±3.8	1.0±2.2	3.0±5.6	1.0±2.2	3.2±4.9	1.4±1.7	0.22[a]
18.3±1.4	19.1±1.9	17.8±2.2	19.1±1.9	18.5±2.2	20.2±2.3	0.06[a]
322±74	310±82	364±81	310±82	345±82	344±49	0.25[a]

Table 5. Unadjusted and adjusted odds associated with musculoskeletal injury for Military Occupational Specialty for male respondents

Variable	Variable level	n	% Injury	Unadjusted odds ratio (95%CI)	p-value	n	Adjusted odd ratio (95%CI)	p-value
Age (y)[a]	18-21	446	40	1.00				
	22-25	559	47	1.34 (1.04-1.73)	0.02			
	26-32	583	47	1.34 (1.05-1.72)	0.02			
	≥33	536	51	1.62 (1.25-2.09)	<0.01			
BMI (kg/m2)[a]	≤24.99	663	43	1.00		501	1.00	
	25-27.49	643	42	0.97 (0.78-1.21)	0.80	489	0.88 (0.68-1.14)	0.32
	27.5-29.99	447	50	1.31 (1.03-1.67)	0.03	329	1.26 (0.95-1.68)	0.12
	≥30	356	55	1.61 (1.24-2.08)	<0.01	248	1.43 (1.04-1.97)	0.03
Tobacco	Non-Smoker	1742	47	1.00				
	Smoker	382	43	0.84 (0.67-1.04)	0.11			
Sleep (h/ night)a	≤4	283	60	2.22 (1.56-3.15)	<0.01	193	1.81 (1.17-2.80)	<0.01
	5	498	47	1.29 (0.94-1.76)	0.12	363	1.13 (0.77-1.66)	0.54
	6	666	44	1.16 (0.86-1.56)	0.34	510	1.11 (0.77-1.60)	0.58
	7	437	44	1.16 (0.84-1.59)	0.38	337	1.19 (0.80-1.76)	0.39
	≥8	240	40	1.00		164	1.00	
Foot marching (miles/mth)	None	725	46	1.01 (0.78-1.31)	0.94			
	1-4	347	43	0.87 (0.64-1.18)	0.36			
	5-6	416	43	0.89 (0.67-1.19)	0.44			
	≥7	345	46	1.00				
Weight training (min/wk)	0	378	46	0.92 (0.69-1.25)	0.61			
	1-59	347	42	0.78 (0.57-1.06)	0.11			
	60-150	380	47	0.98 (0.73-1.31)	0.87			
	≥ 151	323	48	1.00				
MOS Group	Field & Air Defense	169	29	1.00		140	1.00	
	Support & Administration	43	35	1.31 (0.65-2.67)	0.45	31	1.28 (0.54-3.00)	0.58
	Signals & Comms	136	41	1.71 (1.07-2.76)	0.03	115	2.18 (1.27-3.72)	<0.01
	Military Intelligence	120	43	1.81 (1.11-2.30)	0.02	101	2.00 (1.14-3.48)	0.02
	Armor	65	45	1.97 (1.09-3.56)	0.02	39	2.48 (1.17-5.22)	0.02
	Engineers	402	45	1.99 (1.35-2.92)	<0.01	327	2.69 (1.73-4.19)	<0.01
	Transportation	125	46	2.12 (1.31-3.44)	<0.01	83	2.78 (1.55-4.98)	<0.01
	Military Police	105	47	2.14 (1.29-3.56)	<0.01	93	2.61 (1.48-4.59)	<0.01
	Repairer & Maintenance	398	50	2.45 (1.67-3.60)	<0.01	270	2.59 (1.64-4.08)	<0.01
	Infantry	110	50	2.45 (1.49-4.04)	<0.01	68	2.38 (1.28-4.44)	<0.01
	Supply & Logistics	243	52	2.64 (1.74-4.00)	<0.01	149	2.88 (1.74-4.77)	<0.01
	Medical	121	52	2.66 (1.63-4.33)	<0.01	89	2.78 (1.57-4.94)	<0.01
	Chemical Warfare	87	62	4.01 (2.32-6.92)	<0.01	62	5.28 (2.76-10.10)	<0.01
Physical demand level	Moderate	1208	47	1.08 (0.87-1.34)	0.49			
	Significant	467	50	1.21 (0.98-1.50)	0.08			
	Heavy	449	45	1.00				
Medical and fitness team	No	393	47	1.03 (0.82-1.28)	0.82			
	Yes	1679	46	1.00				
ACFT total scorea (points)	≤431	421	53	1.56 (1.16-2.09)	<0.01	420	1.54 (1.14-2.09)	<0.01
	432-469	431	44	1.09 (0.81-1.46)	0.56	430	1.09 (0.80-1.47)	0.60
	470-506	397	39	0.89 (0.66-1.20)	0.43	397	0.90 (0.66-1.22)	0.50
	≥507	320	42	1.00		320	1.00	

Note: [a] Linear trend. Variables run in adjusted model: BMI, sleep, MOS and ACFT score. kg, kilogram; m, metre; min, minute; h, hours; wk, week; mth, month; y, years; MOS, military occupational specialty.

Table 6. Unadjusted and adjusted odds associated with musculoskeletal injury for Military Occupational Specialty for female respondents

Variable	Variable level	n	% Injury	Unadjusted odds ratio (95%CI)	p-value	n	Adjusted odd ratio (95%CI)	p-value
Age (y)	18-21	102	54	1.00				
	22-25	114	62	1.41 (0.82-2.43)	0.21			
	26-30	91	60	1.31 (0.74-2.32)	0.36			
	≥31	113	62	1.39 (0.81-2.40)	0.23			
BMI (kg/m2)	≤24.99	217	59	1.00		142	1.00	
	25-27.49	126	51	0.70 (0.45-1.10)	0.12	79	0.84 (0.47-1.50)	0.55
	≥27.5	75	75	2.01 (1.12-3.62)	0.02	41	2.42 (1.07-5.46)	0.03
Tobacco	Non-Smoker	385	59	1.00				
	Smoker	35	66	1.32 (0.64-2.73))	0.45			
Sleep (h/night)	≤4	59	54	0.54 (0.25-1.13)	0.10			
	5	114	62	0.75 (0.39-1.45)	0.39			
	6	120	57	0.59 (0.31-1.14)	0.11			
	7	66	58	0.61 (0.31-1.27)	0.19			
	≥8	61	69	1.00				
Foot marching (miles/mth)	0	138	58	1.54 (0.87-2.71)	0.11			
	1-4	59	63	1.87 (0.93-3.77)	0.07			
	5-6	56	64	2.01 (0.98-4.09)	0.06			
	≥7	74	47	1.00				
MOS Group	Military Intelligence	41	49	1.00		29	1.00	
	Support & Administration	29	52	1.13 (0.43-2.91)	0.81	10	0.88 (0.19-4.03)	0.46
	Engineers	46	54	1.25 (0.54-2.91)	0.60	35	1.79 (0.64-5.06)	0.27
	Transportation	26	58	1.43 (0.53-3.85)	0.48	16	1.71 (0.47-6.19)	0.42
	Chemical Warfare	35	60	1.58 (0.63-3.92)	0.33	25	2.18 (0.71-6.8)	0.18
	Medical	57	61	1.67 (0.74-3.76)	0.22	32	1.94 (0.68-5.59)	0.22
	Military Police	29	62	1.72 (0.65-4.53)	0.27	24	3.83 (1.16-12.64)	0.03
	Supply & Logistics	103	63	1.80 (0.86-3.73)	0.12	56	1.83 (0.71-4.74)	0.21
	Repairer & Maintenance	33	67	2.10 (0.81-5.42)	0.13	21	3.17 (0.94-10.69)	0.06
	Signals & Comms	21	71	2.63 (0.85-8.11)	0.09	14	1.61 (0.42-6.15)	0.49
Physical demand level	Moderate	215	61	1.24 (0.69-2.23)	0.47			
	Significant	147	61	1.24 (0.68-2.30)	0.48			
	Heavy	58	55	1.00				
Medical and fitness team	No	101	64	1.26 (0.79-2.01)	0.34			
	Yes	302	59	1.00				
ACFT total score (points)	≤291	66	62	2.15 (1.07-4.30)	0.03	66	2.16 (1.03-4.50)	0.04
	292-330	65	62	2.10 (1.05-4.20)	0.04	64	2.23 (1.07-4.64)	0.03
	331-391	66	64	2.29 (1.14-4.60)	0.02	65	2.26 (1.08-4.74)	0.03
	≥392	67	43	1.00		67	1.00	

Note: Variables run in adjusted model: BMI, MOS and ACFT score. kg, kilogram; m, metre; min, minute; h, hours; wk, week; mth, month; y, years; MOS, military occupational specialty.

injury incidence was 46.3% for males and 59.6% for females (overall injury incidence was 48.6%). Therefore, females had a 29% higher risk of being injured compared with males (Risk Ratio 1.29, 95% Confidence Interval, 1.18-1.41, p<0.01)

The percentage of males and females by MOS group and the corresponding self-reported MOSs are reported in Table 1. The percentage of males and females by physical demand categories of moderate, significant and heavy, along with corresponding MOS groups, are reported in Table 2. Additionally, the IFT and IOC ACFT event standards for each physical demand category are displayed in Table 2. Most respondents had a physical demand workload of moderate (106/139 individual MOSs). Approximately 45% of soldiers' most recent ACFT was performed under the IFT ACFT standards and 55% was performed under the IOC ACFT standards.

Age, BMI, health behaviour, physical training, injury, soldiers augmented with a medical and fitness team, physical demand level and physical fitness data by MOS group for male respondents are reported in Table 3. Supplementary Table 1 reports MOS group comparisons of continuous and frequency data. The distribution of males taking the IFT ACFT was 44%, with an average ACFT score of 450±69 points. The distribution of males taking the IOC ACFT was 56%, with an average ACFT score of 460±71 points.

Age, BMI, health behaviour, physical training, injury, soldiers augmented with a medical and fitness team, physical demand level and physical fitness data by MOS group for female respondents are reported in Table 4. Supplementary Table 2 reports MOS group comparisons of continuous and frequency data. The distribution of females taking the IFT ACFT was 49%, with an average ACFT score of 331±75 points. The distribution of females taking the IOC ACFT was 51%, with an average ACFT score of 334±86 points.

Univariable and multivariable logistic regression analyses examining musculoskeletal injury risk for male respondents are reported in Table 5. In the univariable analysis, all MOS groups, compared to Field and Air Defense Artillery (except for Support and Administration group), had 1.7 to 4.0 times higher risk of a musculoskeletal injury. There was a linear trend for injury pertaining to these same variables (age, BMI, sleep and ACFT score; $p < 0.05$; Table 5). In the multivariable analysis, when compared to Field and Air Defense Artillery (except for Support and Administration), all MOS groups had 2.0 to 5.3 times higher risk of a musculoskeletal injury when controlling for BMI, sleep and physical fitness. The multivariable model did not include age due to a significant correlation with BMI ($p < 0.05$).

Univariable and multivariable logistic regression analyses examining musculoskeletal injury risk for female respondents are reported in Table 6. In the univariable analysis, females with the highest BMI and those with lower ACFT total scores had a higher risk of musculoskeletal injury. There were no linear trends for injury in relation to demographics, health behaviours, physical training, MOS group, physical demand level and physical fitness. In the multivariable analysis, when controlling for BMI and physical fitness, the Military Police MOS group had a 3.8 times higher risk of musculoskeletal injury when compared to the Military Intelligence MOS group. The multivariable model did not include age due to a significant correlation with BMI ($p < 0.05$).

Discussion

The current investigation describes demographics, health behaviours, physical training, physical demand level, the per cent of soldiers augmented with a medical and fitness team, physical fitness and injury incidence by MOS group. Additionally, the association between MOS group and musculoskeletal injury risk was explored. Among the MOS groups, there were differences in demographics, physical training, health behaviours, the percentage of soldiers augmented with a medical and fitness team, injury incidence and physical fitness as measured by the ACFT. When controlling for known injury risk factors, the MOS groups of Field and Air Defense, and Military Intelligence had the lowest injury rates for men and women, respectively.

BMI has been shown to increase with age and is associated with physical performance.[22,23] The current investigation found similar relationships between age and BMI among the MOS groups. Regarding physical performance, the Infantry group was the most physically fit (based on ACFT performance) among all the MOS groups yet had the highest average BMI. They did, however, perform the most weight training per week (along with the medical group) and the greatest amount of foot marching per month. It may be that the Infantry Soldiers had more muscle mass and greater amounts of fat mass,[24] but low enough levels of fat mass not to impede physical performance. In addition, higher BMIs were also a risk factor for injury. This is similar to other studies investigating BMI and injury risk.[11,23]

US Army Soldiers are susceptible to sleep inadequacies such as short sleep duration and poor sleep quality.[25] Sleep loss can impair cognition, mental wellbeing and recovery.[26] Habitually sleeping less than seven hours per night increases musculoskeletal injury risk.[6] The current investigation revealed no MOS group differences but found that ≤4 hours of sleep per night increased musculoskeletal injury risk for male soldiers, as observed in another military study.[6]

Smoking has been associated with higher injury risk, smoking-related illnesses, lower aerobic performance, higher healthcare costs, lost productivity and attrition.[27-33] In the current investigation, male Air and Field Defense and Armor Soldiers reported the highest percentage of smokers at 26%. In the 2020 US Army Health of the Force report, 17% of soldiers reported using smoking products (e.g. cigarettes, cigars, pipes, etc.)[12] It is not known why these specific MOS groups had higher proportions of smokers. However, onsite smoking cessation programs offered through medical facilities and military wellness centres can assist with smoking cessation programs. In addition, smoking did not influence the odds of musculoskeletal injury in this investigation. The literature on smoking and injury risk can be diverse, with some studies showing an increased risk of a musculoskeletal injury among smokers while others show no risk of a musculoskeletal injury.[34 35]

Modifiable factors, such as physical training and fitness level, may be influenced by the addition of a medical and fitness team, personnel turnover, change in leadership intent and the current mission set of a unit. The most notable physical training and fitness (as assessed by ACFT performance) differences between MOS groups were among male respondents. Male Infantry and Medical MOS groups reported the most personal weight training per week, while Support and Administration reported the least weight training per week. Higher amounts of weight training, as seen in Infantry, may be due to the higher physical demands of job duties. With a recent transition to physical fitness testing that includes strength-specific measurements, some units have prioritised strength training and dedicated more time per week to improving strength.

Furthermore, the miles foot marched per month differed between MOS groups. Male Infantry Soldiers reported the highest amount of foot marching per month. This is expected since travelling by foot, manoeuvring and carrying heavy loads is a frequent part of the Infantry mission.[2] Interestingly, female Transportation Soldiers reported the most miles foot marched per month and the least time weight training. The higher foot marching mileage per month may have caused more muscle soreness and fatigue, leading to less personal weight training time for the Transportation group. The Transportation group may have been preparing for an upcoming deployment with more foot marching per month. It has been recommended that carried loads and distance marched gradually increase and that recovery periods allow the body to recuperate from the conditioning stimulus to avoid injury.[36] It is also recommended that other military tasks and physical conditioning programs be considered part of any load carriage conditioning program.[37]

Historically, Infantry Soldiers outperform non-Infantry Soldiers on physical fitness tests.[11] These observations were supported in the current investigation. Infantry Soldiers had the highest performance for each of the six ACFT events, along with the highest overall score.[2] Greater physical–occupational demands would compel a more rigorous physical training program to meet mission requirements. Overall, different mission requirements of each MOS group would influence the frequency, intensity and duration of physical training, thereby influencing physical performance.[38]

Compared to other health conditions, injuries cause significant morbidity among US Army Soldiers, with over two million medical encounters a year.[12,39] Previous studies have also shown higher injury rates for females compared to male service members,[5,15] similar to the current investigation. However, no difference in injury rates among males and females has been shown when controlling for age, body fat, physical fitness and occupational demand.[40] In the current investigation, overall injury incidence (48.6%) was comparable to other US Army operational units, with injury incidence ranging from 35% to 69% over a one-year period.[19,41] The range of injury incidence by MOS group was considerably large and varied from 29% to 62% for males and 49% to 71% for females. Similarly, a Light Infantry brigade of male US Army Soldiers reported a large injury incidence range of 36 to 60% among the different MOS groups.[11] Differences in age, demographics, health behaviours, physical training, physical fitness, environment and mission requirements may provide some explanation of the wide range of injury rates between the different MOS groups.

Similar to previously reported data, leading areas of injury included the knee and lower back for both males and females.[42] Male Field and Air Defense, Armor and Infantry Soldiers had the lowest incidence of lower back injuries and higher than average ACFT fitness performance. In a study of firefighters, higher levels of physical fitness had a significant protective effect against back injuries.[43] Additionally, in a systematic review and meta-analysis, patients with lower back pain had less lower limb strength when compared to healthy controls.[44] Higher fitness levels, including muscular strength, may be protective against lower back injuries.

Lower levels of aerobic endurance running, greater than 20 miles per week, prior injury, older age and elevated BMI have been associated with higher running-related injury risk.[45-47] Contrary to having the lowest running-related injury rate, the Medical MOS group had one of the slowest 2-mile run times, indicative of lower aerobic endurance, compared to the other MOS groups. Even though the number of miles run per week during personal physical training was similar among the MOS groups, the intensity most likely varied between the groups, resulting in different levels of aerobic endurance. The differences in running-related injury rates among the MOS groups may have been influenced by multiple risk factors associated with running-related injuries.[47]

Male Field and Air Defense Artillery Soldiers had the lowest risk of a musculoskeletal injury compared to all other MOS groups (except Support and Administration) when controlling for known risk factors. Field and Air Defense Artillery Soldier demographics, physical training and performance metrics were similar to the overall MOS average metrics. It could be that the Field and Air Defense Artillery's overall mission and moderate physical demand level contributed to their lower injury rates. In a previous study of US Army MOS groups, Infantry Soldiers had the lowest risk of injury compared to other MOS groups.[11] Infantry Soldiers in this previous investigation were the youngest group, had the lowest average BMI and were the most fit. Younger age, lower BMIs and higher aerobic endurance have been shown to be protective against musculoskeletal injury.[5]

Female Military Intelligence and Electronic Warfare Soldiers had the lowest risk of musculoskeletal injury compared to the females in the Military Police MOS group when controlling for known risk factors. Both Military Intelligence and Military Police MOS groups have the same physical demand level of moderate, however, their overall missions are different and may have contributed to the dissimilarities in injury rates. In a previous Air Force Security Forces personnel study, injury incidence was 65% over seven years. The most common injured body areas were the knee and lumbar spine.[48] In a study of Military Police recruits, injury during training was 34.2% for males and 66.7% for females.[49] These previous studies also indicated similar injury rates for Military Police personnel compared to the current study. Injury risk factors specific to Military Police recruits were being older, smoking in the past and those who performed less frequent exercise or sports prior to training.[49]

The current investigation did have limitations. The sample size for female soldiers became small when stratified by MOS groups, leading to lower statistical power. Data obtained from the survey was self-reported, which has the potential for biases or inaccuracies. However, moderate to high correlations have been found between actual and self-reported height and weight, physical training and physical performance.[50,51] A complete understanding of respondents' lifestyles was not obtained. Future studies should include metrics about other behaviours, such as alcohol consumption and medication use. Additionally, future investigations examining MOS group differences should ask about the current deployment cycle status to account for periods of increased occupational duties. The percentage of soldiers augmented with medical and fitness teams varied among the MOS groups, making it difficult to determine their influence on health behaviours, physical training and physical fitness. Future studies should examine soldiers with and without medical and fitness teams to determine the influence on soldiers' health behaviours, physical training and physical fitness. Lastly, the ACFT scoring system was slightly modified during the investigation, but the changes in points by performance event were minimal.

Conclusion

Injuries are the leading threat to health and lost work days in the military services.[52,53] Injury incidence among the MOS groups and physical demand levels varied greatly for males and females. For males, there were also notable differences in age, anthropometrics, health behaviours, physical training and physical fitness between the MOS groups. MOS groups with the lowest injury incidence were males in Field and Air Defense Artillery and females in Military Intelligence and Electronic Warfare. Surveillance of injury incidence and physical fitness, along with health behaviours and physical training by MOS groups, may be used to focus injury prevention strategies and reduce lost work time.

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Supplementary Table 1. Group comparison of Military Occupational Specialty Groups by demographics, health behaviours, physical training, physical demand level, injury and physical fitness data for male respondents

	Field and Air Defense Artillery (A)	Support and Admin (B)	Signals and Comms (C)	Military Intelligence and Electronic Warfare (D)	Armor (E)	Engineers (F)	Transportation (G)	Military Police (H)	Repairer and Maintenance (I)	Infantry (J)	Supply and Logistics (K)	Medical (L)	Chemical Warfare and Explosives Ammunition (M)
Age, BMI, Health behaviours, Physical training and per cent augmented with a medical and fitness team													
Age [a]		F	F	F			-	A, E, F	F	A, E, F	F	A, E, F, I	-
BMI [a]	-	-	-	-			-	F	-	E, F	F	F	-
% Smoker [b]	K	-	-	-	K	-	-	-	K	-			-
Weight training (min/wk) [a]	-		-	G	-			-		B, F, G, I, K		B, F, G, I, K	-
Foot marching (miles/mth) [a]		-				D, I, K	-	-		A, C, D, E, I, K, L			-
% Soldiers with a medical and fitness team	B, C, H, I, J, K, L, M	-	-	B, C, H, J, K, L	B, C, H, J, L	B, C, G, H, I, J, K, L, M	B, C, H, J, L	C	B, C, H, J, L	C	B, C, H, L	C	B, C, L
Physical demand level													
% Heavy [b]	I	-	-	-	A, F, I, K	A, I, K	A, F, I, K	-		A, F, I, K		-	-
% Significant [b]	-	C, F, G, I		-	-			B, C, F, G, I, K, L	C, F, G	-	C, F, G, I	C, F, G, I	-
% Moderate [b]	B, E, F, G, H, I, J, K, L	E, G, H, J	B, E, F, G, H, J, K, L	-		E, G, H, J, K			B, E, F, G, H, J, K, L		G, H	E, G, H, J	-
Injury (medical record)													
% Injury [b]		-	-	-	-	A	-	-	A	A	A	A	A
Top three self-reported injury activities													
% Running [b]	-	-	-	-	-	-	-	-	-	-	L		-
% Occupational [b]	-	-	-	-	-	-	-	-	-	-	-	-	-
Army Combat Fitness Test													
DL (lbs) [a]				-				-		A, B, C, E, F, G, I, K, M		-	
SPT (m) [a]	-	-	-	-		-	-	-	-	E	-	-	-
HRPU (rep) [a]					I, K	I, K	I	-		A, B, C, D, I, K, L, M			
SDC (min) [a]	-	-	-	-	-	-	-	-	-		J	-	-
LT (rep) [a]	-			-	-		-	-		B, C, F, I, K		-	-
2MR (min) [a]	-	-	-	-	-		-	-	F	-	-	-	-
Overall Score (pts) [a]	-			-	-	-	-	-		B, C, I, K		-	-

Note: A=Field and Air Defense Artillery, B=Support and Administration, C=Signals and Communications, D=Military Intelligence and Electronic Warfare, E=Armor, F=Engineers, G=Transportation, H=Military Police, I=Repairer and Maintenance, J=Infantry, K=Supply and Logistics, L=Medical, M=Chemical Warfare and Explosives Ammunition. a The mean difference is significant at the 0.05 level (MOS in column header vs corresponding MOS designated letter) using a one-way ANOVA with a Tukey post hoc test. For each significant pair, the letter with the smaller category appears in the category with the larger mean. b Frequencies differences are significant at the 0.05 level (MOS in column header vs corresponding MOS designated letter) using chi-squared pairwise comparisons with a Bonferroni correction. For each significant pair, the letter with the smaller column proportion appears in the category with the larger column proportion. -, represents no significant difference or no comparisons because the column proportion is equal to zero; min, minutes; wk, week; mth, month; lbs, pounds; m, metres; rep, repetitions; pts, points.

Supplementary Table 2. Group comparison of Military Occupational Specialty Groups by demographics, physical demand level and physical fitness data for female respondents

	Military Intelligence and Electronic Warfare (A)	Support and Admin (B)	Engineers (C)	Transportation (D)	Chemical Warfare and Explosives Ammunition (E)	Medical (F)	Military Police (G)	Supply and Logistics (H)	Repairer and Maintenance (I)	Signals and Comms (J)
Age, Physical training and per cent augmented with a medical and fitness team										
Age [a]	-	C, E, H		-		-	-		-	-
Foot marching (miles/ mth) [a]	-	-	-	H, I, J	-	-	-			
% Soldiers with a medical and fitness team	B, F, G, J		B, F, G, J	F	B, F, G, J			B, F, G, J	F	
Physical demand level										
% Heavy [b]	-	-	H	H	-	-	-		-	-
% Significant [b]	-	C, D, I, J			-	C, D, I, J	C, D, F, H, I, J	C, D, I, J		
% Moderate [b]	-				-	C, D, G		D, G	B, C, D, F, G, H	B, C, D, F, G, H
Army Combat Fitness Test										
DL (lbs) [a]	-	-	-	-	-	-	-	-	-	-
HRPU (rep) [a]	-	-	-	-	-	-	-	-	-	-

Note: A=Military Intelligence and Electronic Warfare, B=Support and Administration, C=Engineers, D=Transportation, E=Chemical Warfare and Explosives Ammunition, F= Medical, G=Military Police, H=Supply and Logistics, I=Repairer and Maintenance, J=Signals and Communications.. [a] The mean difference is significant at the 0.05 level (MOS in column header vs corresponding MOS designated letter) using a one-way ANOVA with a Tukey post hoc test. For each significant pair, the letter with the smaller category appears in the category with the larger mean. [b] Frequencies differences are significant at the 0.05 level (MOS in column header vs corresponding MOS designated letter) using chi-squared pairwise comparisons with a Bonferroni correction. For each significant pair, the letter with the smaller column proportion appears in the category with the larger column proportion. -, represents no significant difference or no comparisons because the column proportion is equal to zero; min, minutes; wk, week; mth, month; lbs, pounds; m, metres; rep, repetitions; pts, points.

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Victorian Naval Warfare, Ships and Medicine 1815 – 1900

N Westphalen

Introduction

Previous articles described the development of a cycle from prehistory to the end of the Napoleonic wars, whereby increasing seaborne trade necessitated larger and more efficient ships. This led to more and better weapons to defend or attack them, thereby creating further trading opportunities.[1,2,3,4,5,6,7] While the technical developments in ships, weapons and medicine often developed independently in multiple regions worldwide, they remained especially closely linked throughout Western history. However, it was not until the 18th century that Western medicine had developed sufficiently for its role in facilitating this cycle to be recognised, thereby making possible the European colonisation of Australia.[8]

This article, chronologically the last of this series, describes the British developments in naval warfare, ships and medicine from 1815 to 1900.[9]

Victorian naval operations

By 1815, Britain had become the pre-eminent maritime power, dominating the world's oceans over the next century. Strategically, this entailed a two-tiered navy, the first comprising battlefleets mainly operating in European waters. These were primarily based in Britain (in particular, Portsmouth, Plymouth and Chatham), which allowed them to blockade northern European ports or bring enemy battlefleets into action and attack their shipping, while defending their own. In addition, its bases at Gibraltar and Malta allowed Britain to likewise dominate the Mediterranean while also safeguarding the trade routes to its Indian, Far East and Australasian colonies (Figure 1).[10]

The second tier comprised a bevy of cruiser squadrons based worldwide, whose wartime role focused on attacking enemy and protecting British (including Australian) trade, the latter from commerce raiders that had evaded the battlefleet blockades or were themselves based overseas.[11] Meanwhile, their peacetime role likewise entailed protecting merchant shipping, albeit through maritime law enforcement (especially against piracy) and hydrographic surveying. They also furthered British interests through 'gunboat diplomacy', such as suppressing the African slave trade and (less altruistically) using force to expand trade with China.[12,13] These squadrons included an East Indies Station from 1744, which began detaching individual ships to Sydney from 1821, and a division thereof from 1848. This became a separate Australia Station from 1859 until the nascent Royal Australian Navy took over its warlike and peacetime functions in 1913.[14,15]

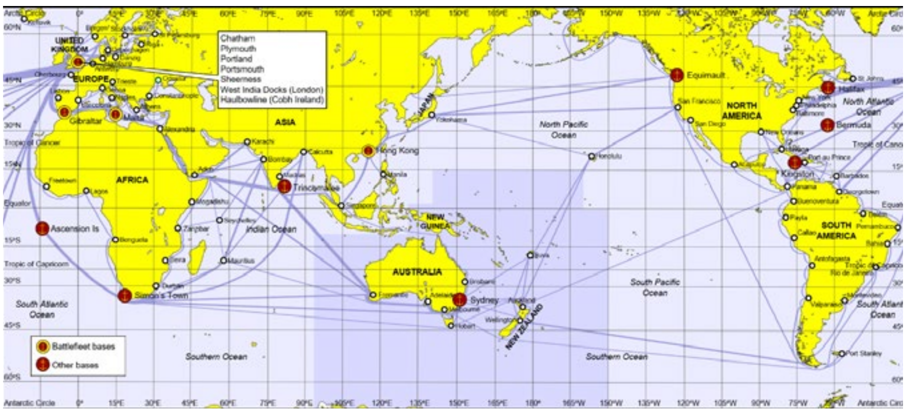

Figure 1. World shipping routes and RN bases, 1900.[16,17] Note their general juxtaposition and the concentration of battlefleet bases in European waters (apart from Hong Kong, whose fleet was withdrawn after 1902). Also note the considerable size of the Australia Station (shaded), and the plethora of shipping routes requiring protection, either in wartime from commerce raiders or peacetime through maritime law enforcement and hydrographic surveying.

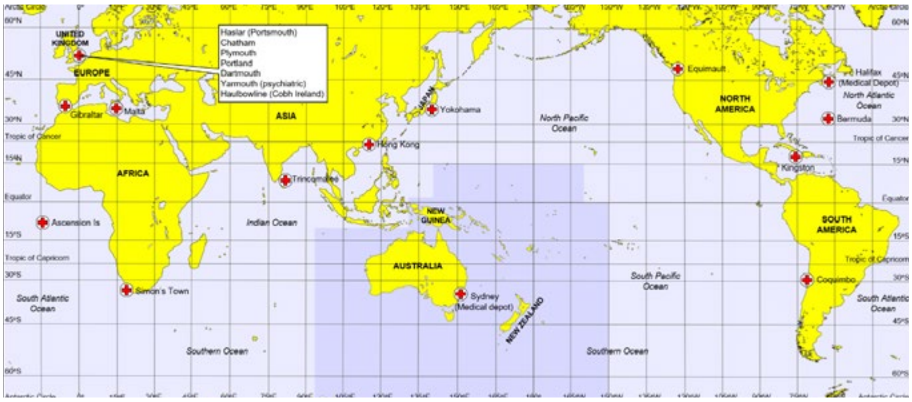

Figure 2. RN hospitals, sick quarters and medical depots, 1900. [22,23] Note their proximity to most (not all) RN bases (Figure 1), and (again) the considerable size of the Australia Station, especially regarding the absence of medical services ashore apart from the major Australasian urban centres. This explains why Sydney had a medical depot, in addition to its sick quarters, to fit out a hospital ship to accompany the local RN squadron in wartime.

While the battlefleet bases each had large and comprehensive naval hospitals (Figures 2–10), the ships they supported had few opportunities to conduct major warlike operations. These were limited to a bombardment of Algiers in 1816 to suppress piracy and the Barbary slave trade; the Battle of Navarino in 1827 (the last to be fought exclusively under sail), which led to Greek independence from the Ottoman Empire; the 1853–56 Crimean War (which also entailed the RN conducting warlike if sometimes desultory operations in the Arctic, Baltic and Pacific); and the 1882 bombardment of Alexandria in Egypt, which ensured British control of the Suez Canal into the 1950s.[18,19,20]

Unlike the ships assigned to the battlefleets, those assigned to the overseas cruiser squadrons usually operated independently in remote locations for days or weeks at a time. This meant that they faced greater infectious disease risks and had more opportunities for combat, but with far less access to medical facilities ashore that could provide better care than on board.[21] Furthermore, depending on each squadron's size, their base medical facilities varied from small outpatient sickbays, inpatient sick quarters for low-acuity cases (as in Sydney, see Figure 11), to fully-fledged if still small naval hospitals supported by the local British Army or civilian medical services.

Figure 3. Royal Naval Hospital Haslar looking east, undated (but probably 1960s); for orientation, see Figure 4.[24] The largest brick-built building in Europe with 1800 beds on its completion in 1762; it was closed in 2008 and has since been converted into apartments.

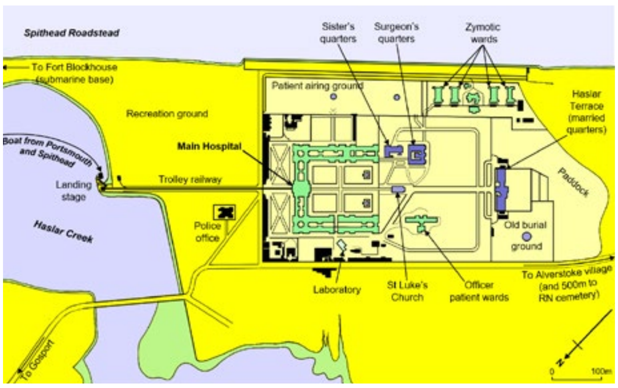

Figure 4. Plan, Royal Naval Hospital Haslar, 1906.[25] (see also Figure 3). Note its ready access to and from ships in Portsmouth Harbour and Spithead (but less so via overland); the trolley railway used to move casualties from the landing stage; the 'zymotic' (isolation) hospital … and the incredibly convenient on-site burial ground and paddock (together containing 8000–20 000 bodies, nearly all in unmarked graves) used from 1757 to 1826, and the proximity to the RN cemetery used thereafter.

Figure 5. Patients and staff, RN Hospital Haslar, pre-1905.[26] Note the gas lighting, with all the ensuing risks from the alcohol, ether and other flammables used on the wards.

Figure 6. Operating theatre, RN Hospital Haslar, 1910.[27] Until then, all surgery had been performed in the wards or side rooms. Note the bay windows to maximise lighting.

Figure 7. Laboratory, RN Hospital Haslar, pre-1896.[28] Note the urinals: one hopes they were used for specimen disposal rather than collection.

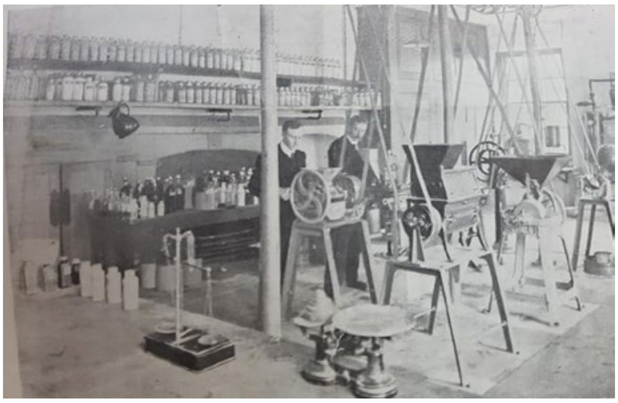

Figure 8. Pharmacy, RN Hospital Haslar, undated.[29] Note the tablet-making machines and the absence of safety guards.

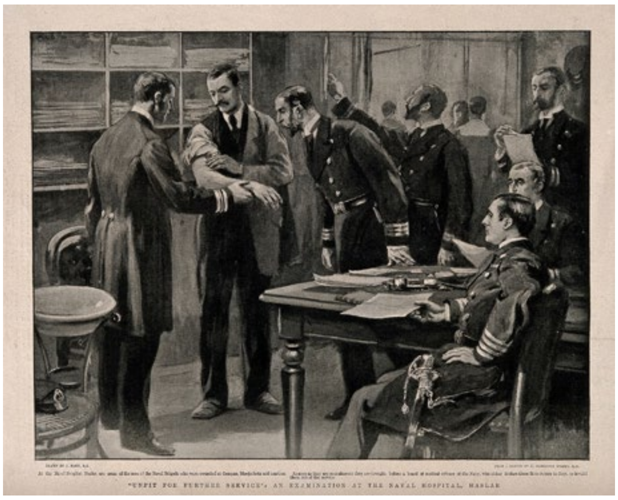

Figure 9. Patient (most likely a Royal Marine), undergoing a Board of Medical Survey (what would now in the ADF be called a Military Employment Classification Review), c.1900.[30] Note the number of medical officers constituting the Board (and the mentoring opportunities created thereby); their level of clinical (not just administrative) engagement with the patient, and the formality of the process (as shown by their dress, and the sword worn by the Board President).

Figure 10. Ex-RN Hospital, Bighi Malta, c.2016.[31] Built in 1832, this 260-bed hospital provided comprehensive health services for the RN's Mediterranean Fleet until its closure in 1970. The site now houses the head office of Heritage Malta. For comparison with an overseas trade protection squadron base medical facility, see Figure 11.

Figure 11. View of the Garden Island Dockyard from the Sydney Domain, c.1900. This had a 13-bed sick quarters on half the top floor of the barracks building (circled), built in 1885.[32] Note the contrast with Haslar and Bighi (Figures 2–10). This sick quarters was only used for xanthomatous and sexually transmitted disease cases, while higher-acuity patients were sent to local civilian hospitals (typically St Vincents or the Royal Prince Alfred). On taking over the dockyard in 1913, the RAN's health services continued to use different parts of the building for various medical purposes until 1990.

Victorian ships

Other articles in this series describe how the development of 'line-of-battle' tactics in the mid-17th century led to warships differentiating into those with two or more gun decks that could take their place therein (hence 'line-of-battle' ships) and those with one gun deck known as 'frigates', which were fast enough to act as fleet scouts, and large enough to attack enemy merchant shipping or defend their own independently.[33,34,35] By 1815, the smallest 'line-of-battle' ships carried 70 to 80 guns compared to 50 to 60 a century earlier, while their gun sizes had also increased; for example, frigates typically carried nine-pounder guns in 1714, but 18- or even 24-pounders a century later.[36,37] These increases required larger ship crews, from around 300 men for 50-gun ships in the 1710s to 550 men for 74-gun ships after the 1780s. The overall number of ships also expanded from around 250 in 1714 to over 900 in 1815.[38] Combined with their larger size allowing these ships to stay longer at sea, these considerations acted synergistically to pose progressively greater wartime challenges for the RN—including its medical services—in getting its ships to sea and keeping them there.

Even so, it is indicative of Britain's peacetime maritime supremacy that it could be sustained with only 20 000 to 60 000 men for 250 to 300 commissioned ships between 1815 and 1889 (Figure 12), with a level of security that eventually even precluded merchantmen having to arm themselves. The ensuing absence of weaponry aboard the latter begat the differentiation between naval and merchant seamen, who heretofore had been generally interchangeable. This, among other factors, led to serious manning shortfalls during the Crimean War, which drove substantial changes to RN sailors' conditions of service, such as the introduction of 12- and 10-year 'continuous service' engagements that finally gave them permanent naval careers.[39] In addition, the RN Reserve was formed in 1859, comprising merchant seamen who had volunteered for periodic naval training, followed in 1902 by the RN Volunteer Reserve (RNVR) for personnel who volunteered for call-up but had no peacetime training liability. The RNVR included medical officers (and dental officers after WWI) and a separate Royal Naval Auxiliary Sick Berth Reserve based on the St John Ambulance.[40,41]

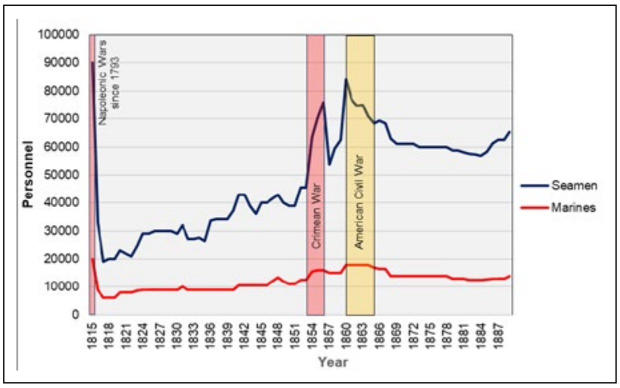

Figure 12. RN personnel requiring medical support, 1815–1889.[42] The two main peaks coincided with the RN's participation in the Crimean War (1853–56) and preparations for a potential conflict with the United States during the American Civil War (1861–65). The increase in seaman (including trainee) personnel most likely reflects the introduction of continuous service from 1853, which augmented the number ashore awaiting their next ship. It should also be noted that nearly all RN ships had a Royal Marine component for gunnery and infantry duties afloat and ashore as part of their complements. A naval arms race after 1889 led to an increase to about 133 000 RN seamen/trainees and marines by 1913.[43]

Although their primary roles remained unchanged, the RN's ships underwent greater technological development during this period than the previous 300 years. Having further increased their size to 100 or even 120 guns, the first steam-powered wooden 'line-of-battle' ships began entering service during the 1850s (Figure 13), while the development of larger guns firing explosive shells led to the first British-built ironclad *Warrior* entering service in 1860 (Figure 14).[44] Subsequent developments saw the abandonment of sail in lieu of increasingly efficient steam engines; the evolution from wooden to iron, then iron-backed steel 'compound' and finally all-steel armoured hulls; and progressively smaller numbers of increasing larger muzzle- and then breech-loading main-armament guns.[45,46] By 1890, these developments had led to the first 16- to 18-knot reciprocating-engined multicalibre 'pre-dreadnoughts', followed in 1906 by the first 21-knot turbine-driven all-big-gun 'dreadnought' battleship (Figures 15–18).

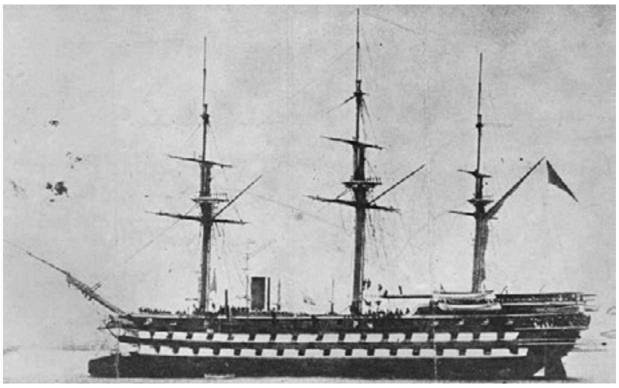

Figure 13. HMVS *Nelson* (2617 tons, c.820 crew, completed 1814) c.1870–1879.[47,48] Initially built as one of the last British 'line-of-battle' sailing ships, with 126 guns on three decks, she was cut down to two decks and given a steam engine in 1860. However, *Nelson* herself never entered RN service, instead being transferred in 1865 to the Victorian Naval Forces as a harbour training ship. Similar ships carried at least one surgeon, two surgeon's mates and, from 1832, at least three ship's company members to act as semi-trained sick berth 'stewards'.[49]

Figure 14. HMS *Warrior* (9137 tons, 707 crew, completed 1861), 2009.[50,51] As the first British-built ironclad warship, she is the ancestor of all RN battleships that served over the next century. She likewise carried one surgeon, two surgeon's mates and probably three ship's company members to act as semi-trained sick berth 'stewards'.[52]

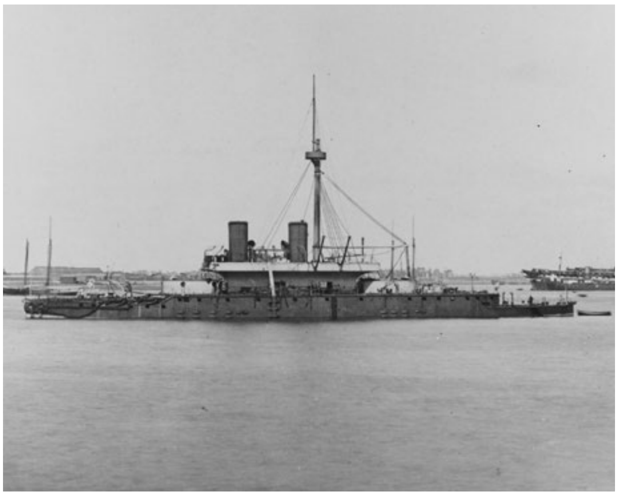

Figure 15. HMS *Thunderer* (9330 tons, 358 crew, completed 1877), c.1879.[53,54] She and her sister *Devastation* were the first battleships designed to operate without sails, for which HMVS (later HMAS) *Cerberus* (3344 tons, 155 crew, completed 1870) had rather acted as a one-third-scale prototype.[55] Both ships carried two surgeons and probably two ship's company members to act as semi-trained sick berth 'stewards' (see also Figures 21 and 22).[56]

Figure 16. Ironclad battleship HMS *Inflexible* (11 880 tons, 440 crew, completed 1881), c.1881–1885.[57,58] This ship represents the pace of technical development during this time, which often rendered ships obsolete on entering service – in *Inflexible*'s case, her sails (10 years after *Cerberus*), iron armour and muzzle-loading guns in en echelon midships turrets. *Inflexible* also carried two surgeons and, probably, up to three sick berth 'stewards'.[59]

Figure 17. *Majestic*-class battleship HMS *Magnificent* (14 890 tons, 672 crew, completed 1895). 1899.[60,61] These and her successors formed the backbone of the RN battlefleets (which precluded their service in Australian waters) from the early 1890s until HMS *Dreadnought* entered service in 1906 (Figure 18). These carried two surgeons (three in flagships) and three trained sick berth attendants.[62,63]

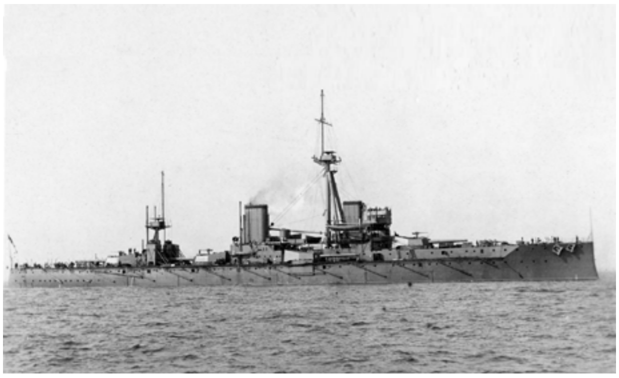

Figure 18. Battleship HMS *Dreadnought* (17 900 tons, 695 crew, completed 1906), c.1908–1911.[64,65] She and her successors formed the backbone of the RN battlefleets until WWII, which also mostly precluded their service in Australian waters. These ships also carried two medical officers (three in flagships) and three sick berth attendants, with a civilian dentist from 1915, thence a RNVR dental officer from 1917.[66,67,68]

These developments also introduced new shipboard hazards (Figures 19–20); for example, electricity in the battleship *Inflexible* in 1881 (Figure 16) inevitably led to the RN's first death by electrocution. These ships had comprehensive sickbays, typically with up to three medical officers and three sick berth staff (Figures 21–23).

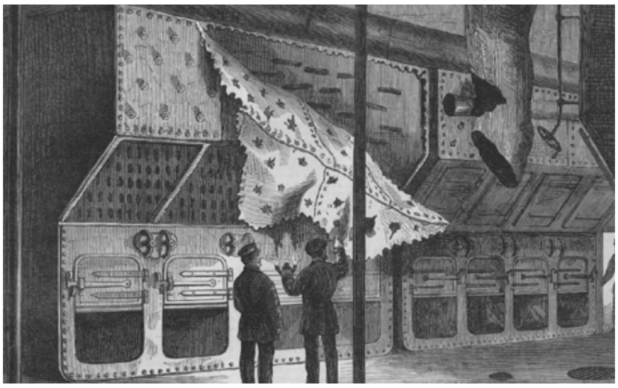

Figure 19. Boiler room damage, HMS *Thunderer*, July 1876. The accident was ascribed to a faulty safety valve, which killed 15 and injured 70 men, 30 of whom later died.[69] *Cerberus*'s boilers were generally identical in design (see also Figure 32).

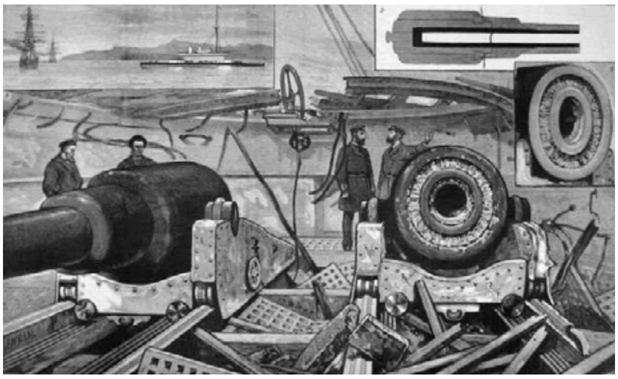

Figure 20. Gun explosion damage, HMS *Thunderer*, January 1879. This accident was ascribed to loading the gun (a muzzle-loader) twice, killing 11 men and injuring 35.[70] Apart from their smaller size (254 rather than 305 mm), *Cerberus*'s guns were generally identical (see also Figure 32).

Figure 21. Sickbay HMS *Warrior* (author, 2022). Note the glass topped operating table (easier to clean than wood before the use of stainless steel), the small stove used for heating and preparing special diets, and the swinging cots for patients. Also note the overhead black iron bars: these were used by the ship's sick berth attendants to sling their hammocks, thereby sharing their living space with their patients at least into the 1940s.

Figure 22. Dispensary HMS *Warrior*, (author, 2022).

Figure 23. Surgical instrument set aboard HMAS *Warrior*, originally owned by Surgeon Adrien Forrester RN (author, 2022). Forrester served on the Australia Station aboard the survey schooner *Dart* from 1901 to 1904, followed by the third-class cruiser *Pyramus* from 1907 to 1911. He died while serving in the pre-dreadnought battleship HMS *Implacable* on 25 April 1915 off Gallipoli.

Meanwhile, the invention of the locomotive torpedo in 1866 led to small and fast 'torpedo boats' during the 1870s and 1880s, which were countered and then replaced by 'torpedo-boat destroyers' (later just 'destroyers') from the 1890s (Figure 24). Their small crews and limited range meant they only needed medical support from their harbour depot ships or alongside until after WWI.[71]

Figure 24. One of the first 'torpedo-boat destroyers', HMS *Daring* (288 tons, 46 crew, completed 1895), 1897.[72,73] Her small size and high speed (26 kts) reflected their primary role of making night torpedo attacks on enemy battlefleets or defending against them. Combined with their short range and limited seakeeping, these roles precluded their use in Australian waters until the 1910s.

The period from 1815 also began with the sail- (and later steam-) driven frigates continuing to be used interchangeably for battlefleet scouting and overseas trade protection. The latter typically entailed these ships acting as squadron flagships for the smaller, if rather eclectically-designated sloops, gunboats and other craft (Figure 25) that undertook surveying, law enforcement and other peacetime roles. By the 1880s, the steam frigate's 'cruizer' trade protection role had been subsumed by three classes of steam-driven 'cruisers' (Figures 26–29), which had higher speed and longer range than battleships at the expense of thinner armour and smaller guns. The RN's first-class 'armoured' cruisers were rendered obsolete in 1907 by the 'battlecruiser' HMS *Invincible* (Figure 30), and the third-class 'protected' cruisers likewise by their small size and limited speed and armament, leaving the second-class cruisers to evolve into the 'light' cruisers used during the World Wars. Their extended operations in remote areas meant that, like the battleships, cruisers had well-equipped sickbays, with up to three medical officers and three sick berth staff, depending on their size.

Figure 25. *Jason*-class wooden screw corvette HMS *Wolverene* (2424 tons, 240 crew, completed 1864) at Sydney, 1881.[74,75] The RN used this type of ship in its smaller overseas squadrons as flagships, wartime commerce protection and peacetime maritime law enforcement, typically in remote areas without shore-based medical support. As the Australia Station flagship from 1875 to 1882, *Wolverine* had a sickbay with two medical officers and, probably, two semi-trained sick berth 'stewards'.[76] Her sister *Orpheus* was wrecked off Auckland while performing the same role in 1863, with the loss of c.166 lives, including the Commander Australia Station, Commodore Sir William Burnett.[77]

Figure 26. Iron armoured frigate HMS *Nelson* (7473 tons, 560 crew, completed 1881) undated.[78,79] The RN used this type of ship in its overseas squadrons as flagships, wartime commerce protection and peacetime maritime law enforcement, typically in remote areas for which *Nelson* still required sails. To these ends, as the Australia Station flagship from 1882 to 1889, she had a sickbay with two medical officers and, probably, up to three sick berth attendants.[80]

Figure 27. Third-class protected cruiser HMS *Wallaroo* (2575 tons, 217 crew, completed 1890) at Brisbane, c.1897–99.[81,82] The RN used these smaller cruisers in its overseas squadrons for wartime commerce protection and peacetime maritime law enforcement, for which *Wallaroo* had a sickbay with a medical officer and a sick berth attendant.[83,84]

Figure 28. Second-class protected cruiser HMS *Cambrian* (4360 tons, 318 crew, completed c.1894), c.1894-1902.[85,86] Note her intermediate size compared to third- (Figure 27) and first- (Figure 29) class cruisers, which gave greater capability than the former at considerably less cost than the latter. The RN used this type of ship in wartime for battlefleet scouting and in its overseas squadrons as flagships and/or wartime commerce protection, typically in remote areas without shore-based medical support. As the Australia Station flagship in 1912-13, *Cambrian* had a sickbay with two medical officers and two sick berth attendants.[87,88]

Figure 29. First-class protected cruiser HMS *Powerful* (14 200 tons, 894 crew, completed 1898), c.1898-1902.[89,90] Note her size (comparable to a pre-dreadnought battleship, see Figure 17) to ensure high speed and long range at the expense of armour and armament. The RN used this type of ship in wartime for battlefleet scouting and its overseas squadrons as flagships and/or wartime commerce protection, typically in remote areas without shore-based medical support. As the Australia Station flagship from 1905 to 1912, *Powerful* had a sickbay with most likely three medical officers and three sick berth attendants.[91,92]

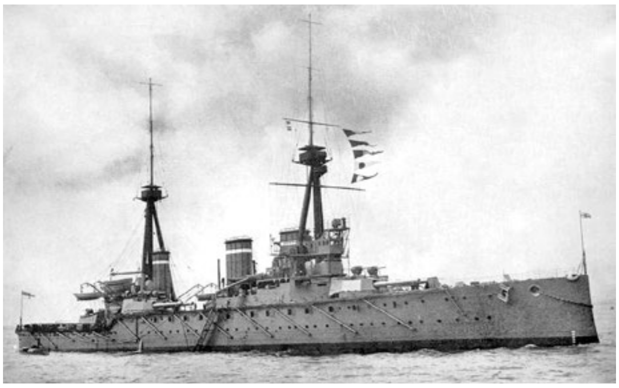

Figure 30. Battlecruiser HMS *Invincible* (17 250 tons, 784 crew, completed 1907), c.1907–1916.[93,94] Note her similarity to *Dreadnought* apart from the same but fewer main-armament guns, the extra funnel indicating extra engine power and the hull scuttles (portholes) indicating less armour, all for greater speed. The RN used this type of ship for battlefleet scouting and commerce protection, resulting in HMAS *Australia* (based on the *Invincible* design) becoming the RAN's first flagship from 1913. To these ends, she had a sickbay staffed in peacetime by two medical officers and four sick berth attendants, with a Permanent List dental officer from April 1918 (11 months before the RN followed suit).[95,96]

Meanwhile, although many of the smaller overseas squadron ships gained steam propulsion as early as the 1840s, their extended periods at sea in remote locations meant that they often retained sails into the 1890s and beyond (Figure 31). Unlike the battlefleet's torpedo-boat destroyers, it was their remote operations rather than crew numbers that necessitated small sickbays for a medical officer and perhaps at least one attendant.

Figure 31. Steel sloop HMS *Torch* (960 tons, c.106 crew, completed 1894), c.1900.[97,98] Note the sail rig (despite her construction 30 years after *Wolverine*, see Figure 25), giving her long range in remote areas. The RN used this type of ship in its overseas squadrons for peacetime maritime law enforcement and hydrographic surveying. *Torch* had a small sickbay with a medical officer and (one would hope) a sick berth attendant.

Victorian naval medicine

Medical advances

As for the RN's ships, the Victorian period saw the greatest changes in medical and surgical practice, albeit over the previous 1600 years rather than 300.

Previous articles in this series explained how Western medicine before the 1850s was based on a 'humoural' disease theory first described in the Greek *Corpus Hippocraticum* between 323 and 31 BCE.[99.] This was expanded by Galen of Pergamon (129–c216 CE), whose pre-eminence impeded further meaningful medical research for the next 1300 years.[100,101] Although effective surgical treatments for uncomplicated cuts, abrasions and limb fractures had been developed by the Egyptians as early as c2000 BCE, further surgical progress was impeded by Galen's anatomical and physiological errors, and the absence of effective analgesia and anaesthesia. As a result, even minor wound complications had high morbidity and mortality rates, while penetrating head, spinal, chest and abdominal injuries remained almost universally fatal.[102]

The first cracks in humoural medicine began with the 16th-century studies by Ambroise Paré, Andreas Vesalius and William Harvey, who, among others, were aided by fewer restrictions on cadaver dissection and the ability to publicise their findings by the invention of moveable-type printing.[103,104,105,106,107] However, progress remained slow until 1847, when, in response to disparate mortality rates between two maternity wards at the Vienna General Hospital, Ignaz Semmelweis directed his medical students to wash their hands between their autopsy studies and ward duties. Six years later, John Snow demonstrated that a cholera outbreak in Soho, London, emanated from a Broad Street water pump. By the 1860s, Louis Pasteur had identified bacteria as the causative agents, which initiated the current 'germ' theory of disease.[108]

Examples of subsequent militarily-relevant research include the identification of the gonorrhoea diplococcus by Albert Neisser in 1879, the tuberculosis bacillus by Robert Koch in 1882, the syphilis spirochaete by Fritz Schaudinn and Erich Hoffmann in 1905 and the rickettsia (typhus) bacillus by Henrique da Rocha Lima in 1916. These discoveries extended beyond bacterial infections when Charles Laveran identified the malaria parasite in 1880, while Ronald Ross ascertained its lifecycle and transmission via the *Anopheles* mosquito in 1897. Although infectious diseases such as yellow fever had first been labelled as 'viral' in 1892, Edward

Jenner had already used the cowpox virus to prevent smallpox in 1796 (a discovery quickly taken up by the RN from 1800), while Pasteur had developed the first vaccine to contain an attenuated live version of a previously dangerous virus in 1885, to prevent rabies. From an RN perspective, perhaps the most dramatic advance pertained to identifying the cause of 'Malta fever' (brucellosis), which reduced incidence rates in the Mediterranean Fleet from 1.89% in 1903 to 0.07% in 1907.[109,110,111,112,113]

Pasteur's research also quickly led to the surgeon Joseph Lister using carbolic acid to disinfect surgical instruments and clean dirty wounds, while further work by Lawson Tait and William Halstead led to the realisation that the key to effective surgical wound care entailed preventing them from becoming infected in the first instance.[114] However, it was not until 1901 that it began to be understood that this meant *all* dead tissue—as found in gunshot and shrapnel wounds—had to be debrided rather than simply disinfected; even then, it only entered mainstream surgical practice after three years of what Arthur Graham Butler called an 'orgy of human vivisection' during WWI.[115]

This realisation became particularly important for treating burns, which had been based on various salves of dubious efficacy since Egyptian times (Figure 32). However, although Guillaume Dupuytren first recognised deaths from the fluid loss associated with large burns in the 1830s, it was only in 1897 that Pierleone Tommasoli used intravenous saline for fluid replacement, while skin grafting did not become accepted practice until after WWI.[116]

Figure 32. Burns case from a shell hit on the Imperial Japanese Navy (IJN) Ship *Matsushima*, during the Battle of Yalu River with the Imperial Chinese Navy on 17 September 1894.[117] Following its formation in 1871, the IJN based itself on the RN (including its medical services) until after WWI. Note the extensive keloid formation, reflecting the contemporary state of burns treatment. See also Figures 19 and 20.

Throughout the Galenic period, patients had been tormented at least as much by their treatment as by their illness or injury. Although opium poppies had been used since antiquity as an analgesic, cough suppressant and anti-diarrhoeal agent, their active

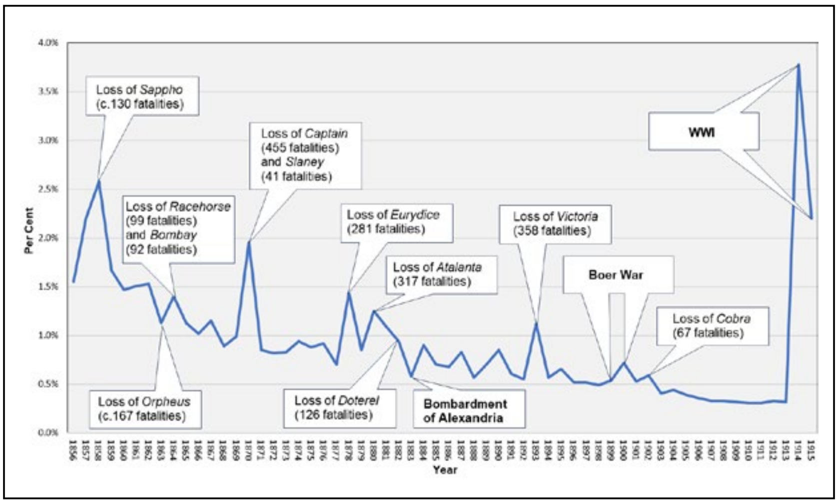

Figure 33. RN mortality rates, 1856–1915.[118,119,120] Note the gradual decline during this period, with the larger peaks often (but not always) reflecting ship losses with large fatality numbers (*Sappho* and *Atalanta* were lost with all hands while *Eurydice* had only two survivors). This graph, therefore, illustrates how RN mortality rates reflected the improvements in naval hygiene and the extent to which the sea posed a greater perennial threat than any human enemy. The smoothing out of the graph from 1904 coincides with the identification and prevention of Malta fever (brucellosis).

agent, morphine, was not isolated until 1804, while the anti-inflammatory agent in willow bark was first synthesised in the form of aspirin in 1899. Following their use as party drugs since the 1790s, ether and nitrous oxide were widely publicised as general anaesthetic agents in 1846, followed by chloroform in 1847. After its isolation from the Peruvian coca plant in 1855, cocaine was first used as a topical anaesthetic for eye surgery from 1884 and as a spinal anaesthetic from 1898. Together, these developments alleviated the more egregious forms of patient suffering and, combined with effective post-operative wound care, led to a surgical revolution that was further enhanced when Wilhelm Röntgen discovered X-rays in 1895.[121,122,123,124,125,126]

The most important medical advances for the RN pertained to naval hygiene, which reduced mortality rates from 2.58% in 1858 to 0.32% in 1913 (Figure 33). To this end, steam power was instrumental, first and foremost by facilitating better ventilation via powered fans to supply trunked 'punkah louvre' forced drafts into engine and boiler rooms and other spaces lacking open-air access.[127] However, although this also facilitated heating the ship's accommodation in cold climates, it was not until after WWII that the RN gave comparable attention to cooling the same spaces in hot climates through air conditioning. Furthermore, the residual role of 'miasma' as part of the humoural theory of disease led to considerably detailed yet medically nugatory meteorological reporting in ship's medical journals into the 1890s.

Steam power also allowed ships to distil their own (albeit still highly rationed) fresh water, which could be stored in the iron tanks that replaced wooden casks after 1815. Besides reducing their reliance on at times dubious sources ashore, readily-available hot water improved personal hygiene through hip- and then plumbed baths for senior officers and 'bird-bath' washbasins for the rest of the ship's company (Figures 34 and 35).[128] However, it was not until after the 1930s that RN ships had showers, and even then, limited fresh water supplies led to 90-second 'wet-and-soap on / wash / rinse-and-soap-off' ablutions into the 1990s (and sometimes beyond). Meanwhile, although *Warrior* had the first seagoing laundry (Figure 36), this was only for engineering sailors and others with dirty jobs, with the rest of the crew using individual 'dhoby buckets' into the 1950s (Figure 37).

Figures 34 and 35. Officer's cabin washbasin unit, ex-battleship *Iron Duke* (commissioned 1914) Lyness Museum (author, 2022). RN ships had surprisingly elementary piped freshwater systems even as late as WWI. This led stewards to carry cans of hot water every morning to each officer's cabin to fill the basin seen here. On completing their ablutions, the officer closed the cabinet, thereby emptying the basin into the tank below for removal by the steward. Meanwhile, the crew shared multiple such basins, which may or may not have had piped outlets. Although an improvement for the latter compared to the sailing ship era, these somewhat sketchy hygiene arrangements often endured into WWII.

Figure 36. Laundry, HMS *Warrior* (author, 2022). Dirty clothes and soap were put in the hexagonal boxes and rotated using the hand crank on the right. The clothes were then wrung out using the mangles above, and the process was repeated sans soap to rinse them. They were then hung in a drying room adjacent to the funnel uptakes, ready for the engineers' next watch in the boiler or engine rooms.

Figure 37. Laundry day, destroyer HMS *Vanity*, October 1940.[129] Notwithstanding *Vanity*'s age (having been commissioned in 1918), this scene would not have looked out of place in *Warrior* 80 years earlier.

This period also saw the development of tinned food in the 1810s (Figures 38 and 39), followed by refrigeration (again made possible by steam power), which was first applied at sea in purpose-built 'reefer' merchant ships during the 1870s.[130,131] Although these developments did not completely preclude the use of lime juice or prevent other vitamin deficiencies, they substantially improved shipboard food preservation, nutrition and dietary variety.

Figure 38. Replica tin of soup, as supplied to the 1845 Franklin Arctic expedition.[132] Although its loss with all hands has been at least partly ascribed to the lead used to seal these tins or to food poisoning from insufficient sterilisation, more recent research (based on morbidity and mortality data from other RN Arctic expeditions during the same period from 1848 to 1854), suggests this is less likely.[133]

Figure 39. Leopold McClintock found this tinned meat while searching for Franklin in 1857–59.[134] Opened in 1926, this is the world's oldest (putatively) edible piece of meat.

While RN personnel were entitled to an alcohol ration since its inception, it was only from 1740 that this became standardised on one gill (142 ml) of up to 97 proof (55.4% abv) rum, diluted 1:3 with water to make 'grog', issued twice daily at 1000–1200 (Figure 40) and 1600–1800. The ensuing high rates of alcohol-related morbidity and disciplinary problems led to the ration being halved in 1825, followed by the afternoon issue being abolished in 1850. While the RAN never had the 'tot' (in place of beer), the RN kept it until 1970, the RCN until 1972 and the RNZN until 1990.[135]

Figure 40. Rum issue, HMS *Royal Sovereign*, 1896.[136] The neat rum was poured from the small cask into the large tub and diluted with water, thereby spoiling it if not consumed immediately . It was then carefully measured into the metal 'fannies' carried by each mess representative, who divided it among their messmates (typically eight men). Despite a high level of accounting and supervision (note the officer on the right), the at times highly creative circumvention and/or illicit use of the 'tot' for bartering purposes led to abuse.

Naval medical administration

A yet-to-be-published article explained how the 17th-century Anglo-Dutch wars led to a series of wartime Sick and Hurt Commissions to fund treatment services ashore, the last of which became a permanent Board in 1714 (80 years before its Army counterpart).[137] Having done surprisingly little to advance the naval medical art, its functions were transferred to the Transport Board in 1806, which was in turn folded into the Victualling Board in 1817.[138,139] This left the RN without a dedicated medical authority ashore until the Admiralty underwent a major reorganisation in 1832. This included a bespoke Medical Department, which had responsibility for the RN's seagoing medical services and ashore for the first time, 64 years before the Royal Army Medical Corps likewise had regarding the British Army's field and base health services.[140] The first Physician of the Navy was Sir William Burnett (Figure 41), who introduced libraries and museums at Haslar and Plymouth (Figure 42), implemented more humane treatment for 'lunatics', and instigated the parliamentary *Health of the Navy* statistical reports from 1830–36, 1837–43 and annually from 1856 into the late 1960s.[141]

Figure 41. Sir William Burnett (1771–1861) c.1841.[142] He joined the RN in 1795 and served at sea in the battles of St Vincent, the Nile and Trafalgar before becoming Physician to the Mediterranean Fleet in 1810. Following a period in private practice, he returned to the RN in 1822 as the Medical Commissioner to the Victualling Board, from which he became the first Physician of the Navy (Medical Director-General from 1843) from 1832 to 1855.[143]

Figure 42. RN Hospital Haslar Museum, undated.[144] Established in 1837 for teaching purposes, the collection was mostly destroyed by German bombing in October 1941.

However, Burnett was less successful regarding surgeon recruiting and retention. Besides considerably lower pay than their Army counterparts, new entrants joined the RN as warrant rather than commissioned Assistant Surgeons until 1843; even then, they continued to be accommodated afloat with the midshipmen and other warrant officers until 1855. Having waited up to 20 years for promotion to surgeon (which gave them commissioned status with wardroom privileges and a cabin (if available) from 1805), they were still ranked behind *every* executive branch officer with minimal opportunities for further advancement. Furthermore, the absence of aged-based retirement throughout the RN meant that in 1840, 63% of all RN surgeons were on half-pay (and hence putatively liable for sea) despite being appointed as far back as 1778.[145]

As a result, Burnett had only 201 surgeons for 328 billets in 227 ships at the outbreak of the Crimean War. The generally less-than-successful expedients that followed resulted in a committee chaired by Vice Admiral Sir Alexander Milne RN in 1866 (Figure 43), which led to surgeons receiving equivalent ranks to executive branch officers (although their titles continued to evolve over the next half-century), and improved pay parity with their Army peers. Even so, recruiting remained problematic (seven candidates for 64 vacancies in 1881) until an 1883 committee chaired by Rear Admiral Sir Anthony Hoskins RN (Figures 44 and 45) fully aligned RN surgeon's pay with Army's and established a separate medical school at Haslar in lieu of sharing the Army's at Netley.[146,147]

Figure 43. Admiral Sir Anthony Milne GBC KBC RN (1808-1896), 1879.[148] Milne entered the RN in 1817 and served on fisheries protection and anti-slavery duties on the North American and West Indies Stations. He moved to the Admiralty in 1847, where his responsibility for transport shipping during the Crimean War gave him a comprehensive understanding of the RN's personnel difficulties. He returned to the North America Station as Commander-in-Chief in 1860 amid diplomatic complications from the American Civil War. Milne first became First Naval Lord in 1866-68 and returned to sea as Commander-in-Chief Mediterranean Fleet from 1869 to 1872, followed by another tenure as First Naval Lord until he retired in 1876.[149]

Figure 44. Rear Admiral Sir Anthony Hiley Hoskins (1828–1901), 1883.[150] Hoskins entered the RN in 1842 and had extensive service, including anti-slavery patrols off West Africa, the Crimean War, the 1860 China War and the 1882 Egyptian campaign. He also served on the North American Station and was appointed Commander Australia Station from 1875 to 1878 after his predecessor, Commodore Sir James Goodenough, died from tetanus after being shot by an arrow in the Santa Cruz Islands. While at the Admiralty in 1880–82, he chaired several personnel inquiries, two of which formed the basis of the RN (hence RAN) medical officer and sick berth attendant career structures over the next century. Hoskins later served at the Admiralty as Superintendent of Naval Reserves and as Commander-in-Chief Mediterranean Fleet in 1889–91, followed by First Naval Lord at the Admiralty, before retiring in 1893.[151]

Figure 45. Medical officers, RN Hospital Haslar, 1890.[152]

Although the sick and injured at sea had been nursed for centuries by their messmates or whoever else was available (including women), most ship's captains were allocating bespoke personnel by 1800. Even so, these typically comprised sailors or marines who were either inclined to care for the sick or injured or deemed useless for anything else. In 1833, the Admiralty formalised these arrangements, adding that these 'sick berth attendants' had to be over 18 years old, physically fit and literate with a good understanding of accounts. This reflected their duties, which (besides omnipresent cleaning), included dispensing, preparing sick diets and assisting with sick mess, medical stores and surgical instrument accounting. However, they had no clinical training apart from whatever their surgeon(s) chose to provide; furthermore, the absence of continuous service meant that their sick berth attendant roles only lasted for their ship's commission (typically three years), with no guarantee of naval employment on coming ashore or even having the same job in their next ship. Meanwhile, the naval hospitals continued to employ untrained women for nursing duties, assisted by casual civilian male pensioners or labourers.[153]

While the introduction of continuous service in 1853 gave 'sickbaymen' the same long-term careers as other sailors, they were still not necessarily employed on medical duties when ashore, while those who typically only undertook 'scrubber' or 'labourer's duties' rather than gaining clinical experience. It was not until 1883 that another committee chaired by Hoskins instituted a formal career structure (based, perhaps rather tellingly, on the steward's branch) for alternating periods of service ashore as well as afloat. Their training entailed 17-year-olds undergoing 18 months of training at Haslar, with their further advancement depending on their satisfactory reporting and examination performance (Figure 46). In 1900, selected 'Chief Sick Berth Stewards' became eligible to become 'Head Wardwasters' (initially one each at Haslar, Plymouth and Chatham), which led to the current RAN Maritime Health Support Officer branch.[154,155]

Figure 46. Sick berth attendants (possibly a class with their instructors), RN Hospital Haslar, c.1910s.[156]

Having also eliminated male pensioners/labourers ashore in place of sickbaymen, the Hoskins Committee also introduced a female-trained women's nursing naval service based on an Army counterpart established in 1881 (Figure 47).[157] This reflected three requirements: the need for better nursing care commensurate with the advances in medical and surgical practice, using nurses to train the sickbaymen, and providing naval continuity should additional female nurses be required to backfill the sickbaymen drawn to sea during wartime. Having begun with 15 members at Haslar and Plymouth in 1884, the RN Nursing Service was renamed the Queen Alexandra's Royal Naval Nursing Service (QARNNS) in 1902. However, they were not liable for overseas service until 1890, did not serve aboard RN hospital ships until 1898, and were not subject to RN discipline until 1977.[158,159]

Figure 47. RN Nursing Service personnel, c.1885.[160] The Red Cross on the right arm was replaced by the QARNNS rank insignia on the right side of the cape after 1902.[161]

Conclusion

This series of articles has explained the connections between warfare, ships and medicine, from prehistory through the Egyptian and Greek, Roman, Viking and medieval periods, and then English (later British) Tudor, Stuart, Georgian and Victorian history. The key common feature relates to maritime trade; the easier and far more cost-effective transport of goods by water compared to land created opportunities to seize them by force, and hence the need to protect them. As humanity advanced from hunter-gatherer tribes to the first settlements, villages, towns, cities and eventually nation-states, these considerations led to escalating competition for the waterborne trade routes on rivers, lakes, estuaries, bays and eventually regional seas, which the Portuguese, Spanish, Dutch, French and English extended to the world's oceans from the 15th century. Over the next 300 years, the last two powers became dominant, with Britain gaining supremacy from 1815. This entailed Britain using its geographic location and overseas bases to control its rivals' trade routes and establish a positive feedback loop whereby its naval power extended the economic power that funded it.

Initially, the role of Western medicine in supporting these developments had a minor role for three reasons. It was only after Europe began to extend its maritime reach into the world's oceans that its ships spent enough time at sea to cause bespoke medical conditions, an effective response to which was impeded by the 1300-year-old dead hand of Galen for another 300 years. The only exception pertained to ships being recognised as disease vectors, for which the bubonic plague or 'Black Death' (1346–53) led to the introduction of quarantine, albeit only to protect those ashore rather than afloat.[162]

Secondly, their separate origins in the 12th century led to a split medical profession between physicians and surgeons, which endured in Britain for over 600 years. The physicians' university training in humoural medicine gave them considerable influence but often limited and even adverse clinical effectiveness, while the surgeons' apprentice-based training produced practical, if at times variable, skills in a subordinate capacity. Hence, although the first English 'sea-surgeons' went to sea after 1512, they could legally only treat injuries and battle casualties, yet were confronted with at times overwhelming numbers of medical cases while the physicians pontificated from ashore.

Thirdly, the absence of differentiation between warships and merchantmen extended to their crews, whose need to defend the latter meant they were essentially interchangeable. Furthermore, as the RN only operated in European waters during the summer months well into the 17th century, the East India Company became the centre of English maritime medicine, which, unlike the RN, was properly funded. Although these considerations created fewer crewing problems for the RN during peacetime, the influx of warships entering service at the beginning and during a conflict, requiring far more seamen than most merchantmen to crew their guns, led to increasingly intense competition for the same scarce trained workforce. Furthermore, gross overcrowding in the warships created high rates of infectious disease, such as typhus, while poorly-preserved victualling and doubtful water supplies led to dysentery. As the RN's ships began operating in the tropics, their crews were also exposed to conditions such as malaria and yellow fever. Meanwhile, as they spent more time at sea, lack of fresh food resulted in vitamin deficiencies such as scurvy.

By the 1740s, the impact of the ensuing losses of scarce trained seamen on the RN's operations had finally become apparent, over a century before the Crimean War led the British Army to a similar conclusion. Even so, it took 50 years for both services to implement the relevant preventive measures. For the RN, this entailed formally implementing the hygiene measures that had been readily apparent for decades, initially via patronage given the lack of other means. For the physicians, this began with James Lind, his disciples Gibert Blane, Thomas Trotter and William Burnett, and thence their respective acolytes. Even so, their efforts regarding *what* measures had to be done would have been for nothing were it not for the executive officers with the authority to direct *how* to implement them. This began with George Anson and his protégés Byron, Howe and Keppel (and their successors such as Cornwallis, Jervis, Collingwood and Nelson), along with James Cook and his followers, including Vancouver and Bligh (and their followers such as Flinders, Franklin, Fitzroy, King and Stanley). Although the hard-won lessons learned were passed on first-, second- and third-hand via this means into the 1850s, subsequent developments reflected the demise of humoural medicine in lieu of the scientific medical advances that followed and an effective naval health administrative system afloat and ashore to promulgate them.

To this end, one of the key features throughout the later period covered by this series relates to the absence of a single agency for the RN's seagoing and shore-based health services. This partly reflected the interchangeable nature of the English seaman's employment between civilian shipowners and the monarch, for which Eleanor of Aquitaine introduced the *Laws of Oléron* in 1189. Although this made all ships' masters liable for the lodging and treatment of their ill and injured crew members, meeting this obligation was perennially impaired by a lack of accommodation. This mainly occurred when that which was available was swamped by non-battle casualties, as occurred after the 1588 Spanish Armada and during Charles I's 1626–29 war with Spain. It was not until the First Anglo-Dutch War (1652–54) that overwhelming battle casualties resulted in this responsibility being assumed by a succession of wartime Sick and Hurt Commissions, with the last becoming a permanent peacetime Board in 1714.

Although these Commissions had introduced the first rudimentary naval medical administrative processes for managing patients ashore, neither they nor the peacetime Board that followed did much more than manage contractors. Escalating costs, poor quality care, and the failure to effectively manage convalescent cases ashore led to the RN's purpose-built hospitals at its battlefleet bases from the 1750s and eventually elsewhere. Following the Sick and Hurt Board's demise in 1806, it was not until 1832 that the RN had a bespoke department that centralised its medical administration ashore and afloat for the first time. This provided the means to advance the naval medical art that supported the RN's worldwide peacetime and warlike operations into and beyond WWII.

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Disclaimer

The views expressed in this article are the author's and do not necessarily reflect those of the RAN or any other organisations mentioned.

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Review Article

Unraveling the Interplay Between Self-efficacy and Decision-making in Military Contexts: A Systematic Review

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Abstract

The success of missions and personnel safety is contingent upon the ability to make effective decisions in the dynamic and high-pressure setting of military operations. This systematic review examines the relationship between self-efficacy and decision making in military settings. Six studies meeting inclusion criteria were identified through a rigorous search of electronic databases and hand searches. These studies varied in design, methodology and participant demographics but collectively revealed a significant association between self-efficacy and decision-making effectiveness in military and similar operational settings. Findings consistently showed that higher levels of self-efficacy were linked to improved decision-making outcomes across diverse tasks and scenarios. However, limitations included diverse methodologies and small sample sizes, warranting the need for further longitudinal research with standardised measures. Overall, this review underscores the critical role of self-efficacy in shaping decision-making processes in military operations and the need for more studies to inform training interventions and leadership strategies to optimise military readiness and performance.

Keywords: Self-efficacy, military decision making, operational background, systematic review.

Introduction

Military units and personnel must contend with uncertainty, high-risk situations, time constraints and dynamic conditions while operating at extremely high levels of physical and psychological strain to stay within ethical, legal and strategic bounds. Making decisions quickly and effectively is essential for navigating in such environments. Decision making is a crucial cognitive function that happens frequently in daily life. A decision is a conclusion drawn from a process that should yield the intended outcomes after careful consideration.[1] Furthermore, the process of making decisions is what moves the efforts in the direction of solving a particular issue. It seeks to accomplish ideal action.[1] Operational research laid the foundation for numerous military decision-making models following World War II.[2]

These models were based on economic theories of utility maximisation, which make the following assumptions: (i) users are rational in their choice of actions; (ii) they are sensitive to differences that distinguish the courses of action; and (iii) they are fully informed about all significant courses of action that apply to a given situation.[3] For instance, military personnel employ the Military Decision Making Process (MDMP), a rational-methodological approach, to solve tactical issues and create military strategies.[4] It developed from the Army's historical 'estimating the situation' method since the Revolutionary War.[5]

Understanding the problem, creating and evaluating several courses of action, selecting the optimal course of action and creating an operation plan or sequence for execution are all steps in the structured planning process known as the MDMP. Therefore, when used appropriately, 'it would lead to the better decision based on the given complexity of the situation'.[6] However, the MDMP's time intensiveness and emphasis on linear, rational decision making raises practical questions because it may not always be appropriate in dynamic, time-sensitive military situations, especially under unpredictable combat situations. For example, an unpredictable enemy raises the risk that there would be 'unknowns' during the operation, which may contribute to the MDMP's expectations being inaccurate.[7]

Alternatively, Klein[8] established the Naturalistic Decision-Making model (NDM), which describes how military operations require 'real-time' decision making under pressure, stress and uncertainty. The NDM was developed in response to the 1988 USS Vincennes incident in which a naval captain cruiser shot down an Iranian passenger plane, thinking it was being attacked by a F-14 fighter jet.[9] Social scientists tried to explain why an experienced, well-trained commander would execute such a wrong decision, and the findings led to the conception of the NMD.[9]

The theory behind NMD postulates that decision-makers in dynamic, high-stake, unstable environments do not have time to think analytically, but their decisions derive from their prior experiences.[10] According to Klein's research on real-world military environments, leaders would deliberate for less than one minute before deciding.[8] Therefore, NDM postulates that training, knowledge, and past experiences would shape the cognitive process of the decision-makers in time-limited and increased uncertain real-war contexts with significant implications of errors.[11] Various perspectives on NDM models have been successfully applied in the military and other organisations over the last 30 years.[12]

Given the time pressure and operations uncertainty, military decision-making is influenced by many psychosocial factors such as stress, training experience, leadership skills, fatigue, personality traits, emotional balance and control, and social factors.[13] The importance of social factors has been documented in military psychology and has shown that they play a crucial role in achieving effective military outcomes.[14] In particular, there is growing evidence that among the most important and pervasive social factors is self-efficacy.[15]

Self-efficacy is people's perception of their ability to perform successfully specific actions in given situations. Self-efficacy is neither a skill nor a personality trait but a perception of how someone mentally perceives his skills to complete a difficult task.[16] Efficacy beliefs are actively shaped by prior experiences and influenced by them.[16,17] The perceived level of self-efficacy impacts motivation and task completion performance.[18] Experience also shapes self-efficacy with comparable circumstances.[19]

Bandura[20] asserts that persons with a high level of self-efficacy in their decision-making skills are better at handling complex decisions. Consequently, efficacy leads to more successful outcomes and better solutions. Self-efficacy relates to a feeling of mastery and control over one's surroundings. Having a high sense of efficacy can help people feel confident and have a positive emotional reaction, which can help them make better decisions in times of crisis.[21]

Bandura proposed the 'belief that complex decision-making is an acquirable skill' (p. 454)[20] to counter this possible detour from making effective decisions. In concordance with this, Bandura warned about decision-making biases from various information sources and feelings.[20] Rather than turning introspective thought to self-doubt and potential cognitive and affective deficiencies, he emphasised that self-efficacy is essential to sustaining concentration on a task and testing multiple options. He promoted inferential reasoning in ambiguous situations, which involves evaluating conclusions based on available data. Metacognitive abilities were critical because they allowed people to concentrate, understand task requirements, evaluate their abilities and modify plans in response to outcomes.[15]

In military psychology, research has indicated that soldiers with high self-efficacy appraisals tend to continue their tasks even under stressful and physically demanding situations.[22] In demanding and unpredictable military operations, perceived self-efficacy is based on previous military experience and conviction in military skills and abilities and is a crucial signal of readiness.[23,24] Recent research has also postulated that military personnel with high self-efficacy may perceive stressful events as a challenge rather than a threat compared to those with lower self-efficacy capacity to handle stressful situations who might experience more adverse emotions, such as anxiety.[25] Self-efficacy is related to effective leadership and collective unit beliefs about combat readiness, motivation and performance.[26,27]

However, despite research documenting benefits, studies assessing decision-making efficiency in military operations concerning self-efficacy have not been reviewed. Given the increasing advocacy for self-efficacy's role in effective decision making, such psychological variables must be reviewed as primary outcome measures and, if possible, in real-world operational contexts. This review aims to systematically assess the influence of self-efficacy on decision-making efficiency within military operations or similar operational contexts. It seeks to fill the gap in existing research by assessing and accumulating research on the impact of self-efficacy on decision-making processes, particularly in high-stress and unpredictable military environments. By analysing relevant literature and potentially incorporating real-world operational data, this study aims to elucidate the role of self-efficacy as a primary psychological factor in shaping decision-making outcomes and informing strategies for enhancing military readiness and performance.

Methods

The guidelines by Siddaway et al.[28] and the Centre for Reviews and Dissemination (CRD) Group[29] were consulted to determine the quality criteria used in this systematic review. Based on these recommendations, the narrative synthesis of results with the tabulation of the data of included studies was used (p. 48).[29]

Searching

A thorough search strategy of electronic bibliographic databases yielded the publications using a list of relevant search terms. Data Bases included Defense Technical Information Center (DTIC), EBSCO Information Services, PsycINFO, PsycARTICLES, Medline (PubMed), Google Scholar and ScienceDirect. Relevant publications and reference lists were also identified through hand searches of journals [Scientific Reports, Military Psychology, Military Medicine, Military Medical Research, Military Operations Research]. The research team came up with search terms during several sessions. The following search terms were combined and paired in different ways: self-efficacy, confidence, social cognition theory, social factors, human factors, decision making, military decision-making, naturalistic decision-making, judgement, performance, training, duty, military, operations, combat, military psychology, aviation, Army, Navy, Air Force.

Selection

Ensuring all essential and relevant articles were included, the inclusion criteria were kept relatively broad. Titles and abstracts were initially included, and if the study was on the military population that concentrated on self-efficacy and seemed to measure decision making, full manuscripts were retrieved for future inspection. Studies on populations, such as pilots in civil aviation who share similar operations with military aviation (e.g., cargo transportation), were also considered. The complete manuscript was retrieved to make an inclusion decision if the titles and abstract did not meet these basic inclusion requirements. The complete manuscripts were then examined, and if the following conditions were satisfied, they were added to the systematic review:

Participants were adults (> 18 years old) who were military personnel, military cadets or civil aviation pilots with similar military operational contexts.

The study measured and reported outcomes on two main psychological variables: self-efficacy and decision making or similar constructs (e.g., measures incorporating decision making as experimental tasks, question items or subscales).

The study clearly described and justified all the information about the potential relationships between self-efficacy and decision making of the studied populations.

The study was available in English full-text version.

Data extraction

Extracted data included year range 2000–2024, participant information (age, military), results (outcome measures, significance), and relevance to the review's aim. To ensure accuracy and reliability, a coauthor independently reviewed each paper.

Quality assessment of included studies

All included studies were subjected to a quality assessment to limit potential bias, allow for comparisons between individual studies, and allow for meaningful conclusions to be drawn. Quality criteria were assessed based on recent recommendations of Protogerou and Hagger[30] for quality assessment of survey research in psychology. Each study was assessed according to the checklist, including 20 quality items in four research domains: Introduction (Rationale); Participants (Sampling); Data (Collection, Analyses, Measures, Results, Discussion); and Ethics—an overall quality score yielded by the equation.[1] Depending on the number of applicable items, scoring cut-offs for an acceptable quality are >75%, >73%, >72% or >70%. Based on these criteria, all studies included were considered of acceptable quality.

$$Overall_{Quality_{Score}} = \frac{Yes_{Scores}}{Total_{Applicable}} x100 \quad {}^{1}$$

Results

The search strategy retrieved 249 articles overall. Afterwards, 38 abstracts were selected based on the title, abstract and keywords. Of those 38 abstracts, 25 were obtained in full-text version. 17 studies were excluded because they did not measure the relationship of the primary outcomes. Two studies were excluded from the final eight because they had a very small sample size (n=6) and needed to report outcome data that it was possible to extract. As a result, six studies (Table 1) were included in this review.

Table 1. Characteristics of included studies (n = 6)

Author, Country, Year of publication	Total (N)	Sample characteristics	Aim	Measurement tools: self-efficacy
Ambrulaitiené, Lithuanian[33]	89	Officers from the Lithuanian ground force. All male. The mean age was 31 yrs. (SD 4.97).	Examining how self-efficacy influence successful military decisions.	Self-efficacy on general scale; self-efficacy in Tactical Leadership Planning (TLP) scale
Boe et al., Norway[35]	141	Military cadets from the Norwegian Military Academy (Army), the Royal Norwegian Naval Academy, and the Royal Norwegian Air Force Academy. 90.2% male, 9.8% female. The mean age was 23.2 years. (SD 2.72).	Investigation of academic self-concept, self-efficacy and military skill acquisition among cadets.	Self-efficacy (SE) scale
Cosenzo et al., USA36	19	Dispatchers at an Emergency Operations Center (EOC). 5 male, 14 female. The mean age was 33.8 years. (19 to 49).	Understanding decision-making processes and self-efficacy in uncertain environments.	Situational Self-efficacy (SSE)
Li et al., China[31]	143	Civil pilots from China Eastern Airlines (CES), with high flight experience. All males. The mean age was 31.36 years. (SD 4.65).	Investigation of self-efficacy's influence on human error among pilots during in-flight missions.	Perceived Professional Self-Efficacy Scale (PPSES) 4 subscales: Adaptation to Situation (AS); Flying Performance (FP); Personal Achievement (PA); Physical State (PS).
Lugo et al., Norway[32]	27	Cyber officer cadets from the Norwegian Defence Cyber Academy 24 male, 3 female. The mean age was 21.7 years. (SD 0.71).	Exploration of self-efficacy and intuitive decision-making styles in cyber defence.	General Self-Efficacy (GSE) scale; Situational Self-efficacy (SSE) scale;
Qiu et al., China[34]	244	Military pilots of a flight brigade with high flight experience. All males. The mean age was 21.99 years. (SD 0.925).	Examining how perseverance and resilience impact pilots' self-efficacy and capacity to handle special flight situations.	Self-efficacy (SE) scale

Measurement tools: decision making	Other measurement tools	Statistical results	Key findings
Military operations evaluation test	-	1. Officers with higher self-efficacy in general and in TLP more often choose successful decisions in specific military tasks (p<.05)	Greater self-efficacy generally leads to more successful decisions in specific operational tasks.
Military skills and abilities: Individual coping capacity (ICC), Cooperation in Difficult Situations (CDS), and Motivation to Achievement (MA).	Academic self-concept (ASC)	1. Higher (ASC) at T1 was associated with higher SE at T2 (R^2 = 0.22, F = 11.16., p <.01), β = 0.26; 2. Higher SE at T2 was associated with higher ICC ($R2$ = 0.43, F= 11.05., p <.01), β = 0.31, higher CDS (R^2 =0.34, F=7.39, p <.01), β = 0.22, higher MA ($R2$ =0.35, F=7.41, p <.01), β = 0.19	High self-efficacy beliefs may longitudinally increase military skills and abilities, including decision-making.
Decision making in a realistic multitask environment (time to complete emergency, police and fire calls)	Need for Cognitive Structure (NCS); Ability to Achieve Cognitive Structure (AACS); Cognitive Uncertainty (CU); Emotional Uncertainty (EU)	1. Significant main effects of NCS, AACS, EU, and CU groups on SSE were found: F (1,20.3) = 4.22, p =.05; F (1,20.3) = 6.30, p =.02; F(1,10.79)= 6.83, p=.02; F(1,9.43) = 6.23, p =.03).	High situational self-efficacy scores related to better decision-making outcomes (less time to complete calls); Dispatchers who scored highly on self-efficacy expressed less anxiety about their performance.
Safety Operation Behavior Scale (SOBS), including a subscale: Situation Awareness and Decision-Making (SADM; 7 items).	Utrecht Work Engagement Scale (UWES) Flight experience	1. Self-efficacy (FP) was significantly associated with human error in Situation Awareness and Decision-Making: -.267, p<0.01; 2. Self-efficacy was significantly associated with the SOBS (human error) the total effect was −.358. 3. Work engagement mediated the relationship between self-efficacy and human error; Direct effect -.218. indirect effect -.141; 4. Self-efficacy was more critical for less experienced pilots (β = 0.507) compared to more experienced pilots (β = 0.290).	Higher self-efficacy: a) reduces human error; pilots' self-efficacy of FP influences decision-making during flight operations; b) indirect impact on pilots' human error through work engagement; c) is critical in predicting human error in less experienced pilots.
The cognitive reflection test (CRT) Interoceptive Sensitivity (cardioactive accuracy)	-	1. Situational Self-efficacy and Interoceptive Sensitivity accounted for significant variance in DMS scores ($R2$ = 0.29, F(2,26) = 4.91, p = 0.008).), β=0.524 2. Interaction between SSE and IS accounted for a significant change in variance in DMS scores (ΔR^2 = 0.101, ΔF(2,26) = 3.819, p = 0.037), β = -0.266, t(27) = 1.954, p = 0.037.	Cyber defence officers with high self-efficacy tend to rely more on intuitive and unaware decision-making, which can impair performance on specific tasks and require deeper reflection.
Test of special flight situation handling capability consisting of three parts (emergency response, decision making and special situation);	Connor Davidson Resilience Scale; Grit Scale, two dimensions: interest and persistence	1. Significant effect of self-efficacy on special situation handling capability through resilience for pilots with high perseverance (β = 0.035, t = 4.13, p < 0.001); (Indirect Effect = 0.08, BootSE = 0.03, 95%CI [0.03, 0.16]).	High persistence scores strengthen the positive impact of self-efficacy on resilience and enhance pilots' capacity to manage special circumstances during flight operations.

Study design

Four studies were cross-sectional,[31–34] while one incorporated experimental methods.[32] Two studies were longitudinal;[35,36] one collected data over three time points (T1, T2, T3) within three years,[35] and the other, a field experiment, within three months.[36]

Participants

As described in Table 1, five studies utilised a military population,[31–33,35,36] while in one study, the population came from civil aviation.[31] The number of participants in each study varied between 19 and 244 (median=115), totalling 663 participants. Of these, only a total of 31 were female. The mean age of all participants was 33.8, ranging from 19 to 49 across studies. Two studies were based in China, two were conducted in Norway, one was undertaken in Lithuania, and the remaining study was conducted in the USA. Additionally, two studies reported average flight experience;[31,34] one study reported that military experience and rank of their military sample were similar to other military academies in NATO without reporting specific statistics,[35] and one study reported other demographic characteristics (e.g., family status).[36] No further specific demographic details were reported in one study.[33]

Measurement tools

As described in Table 1, the included studies reported a variety of research aims and utilised a variety of outcome measures and research designs.[31–36] Self-efficacy was measured using validated self-report measurement tools. Two studies used the Situational Self-Efficacy (SSE) scale,[32,36] while one of these studies used additionally the General Self-Efficacy scale (GSE).[32] Other studies used both the self-efficacy in the General scale to examine the self-efficacy beliefs on specific military tasks and the self-efficacy in the TLP scale measuring perceived capability beliefs in troops leading procedures;[33] the Self-Efficacy scale to examine perceived ability to effectively complete military training and education, which had been developed and validated by the authors;[35] the Self-Efficacy scale to measure the level of participants self-efficacy;[34] and one single study used the Perceived Professional Self-Efficacy Scale (PPSES) a scale specific tailored to pilot's self-efficacy.[31] All included studies reported good psychometric properties of the utilised self-efficacy scales, apart from one study that used a validated measure but failed to report psychometric properties.[36]

Different methodological approaches examined decision making. Three studies examined decision making in specific military tasks.[32–34] Two of the included studies used validated scales that incorporated decision making,[31,35] and one of the included studies assessed decision-making in a real-task operational environment.[36]

More specifically, a study used the Military Operations Evaluation Test of 10 tasks to measure successful and unsuccessful military decision-making.[33] Another included study used the test of special flight situation handling capability consisting of three parts (emergency response, decision making, and special situation), 15 scenarios of special situations with six emerging topics measured for each scenario, including factors influencing the decision-making process and final choices and decisions).[34] Three options were available for each topic: A score of 0 denoted a 'typical wrong choice', a score of 2 denoted the 'best choice', and a score of 1 was assigned to a decision that fell between the two ('typical wrong choice' and 'best choice').

Another study utilised the Cognitive Reflection Test (CRT), a three-question decision-making test.[32] The questions consisted of brief, logical problems with two possible answers: one answer seems 'obvious' and intuitively correct to the participant but is logically incorrect; the other answer is correct but necessitates more thought and inhibits the more 'obvious' primary response tendency. This test, in combination with the Interoceptive sensitivity measured by cardioceptive accuracy, could predict performance on intuition and decision making,[37–39] as reported in Lugo et al.[32]

A study used the Military Skills and Abilities (MSA) scale, comprised of three subscales: Individual coping capacity (ICC), Cooperation in Difficult Situations (CDS) and Motivation to Achievement (MA).[35] Myrseth et al.[40] developed the scale and argued that such factors are crucial for coping and decision making in combat and operational situations. For instance, one question consists of the following statement: 'My ability to make decisions in difficult situations is'. One included study incorporated decision making by using the Safety Operation Behavior Scale (SOBS), consisting of a subscale in Situation Awareness and Decision-Making (SADM; 7 items).[31] This subscale refers to the capacity of pilots to predict and handle unusual or emergencies during flight. The primary focus is on the pilot's awareness of every aspect of the flying environment and his/her efficacy in decision making, risk assessment and feedback modification. Finally, one field study examined decision making in a realistic multitask environment (time to complete emergency, police and fire calls).[36] Other measure scales (e.g., Need for Cognitive Structure [NCS] or Ability to Achieve Cognitive Structure [AACS]) in the study[36] that played a role in the relationship between self-efficacy and decision making were also included and presented in Table 1 to facilitate the interpretation of the results.

Quantitative analysis and findings

The studies used similar statistical methods to assess the research questions, which were judged to be appropriate for the study designs utilised. Specifically, two studies tested mediation/moderation effects,[31,34] while one applied additional correlational analysis of all critical variables.[31] Two studies utilised hierarchical regression analysis,[32,35] while one applied moderation analysis.[32] Finally, one study used mixed linear model analyses,[36] and one study used Mann-Whitney tests.[33] As presented in Table 1, all studies yielded significant results, while five out of six reported effect sizes.[31,32,34–36] One study additionally reported a good achieved test power.[32] Statistical results and key findings of each study are presented in Table 1.

Discussion

The literature evaluating the influence of self-efficacy on military decision-making is relatively sparse. This systematic review identified only eight studies for inclusion; however, two of these did not provide sufficient detail to be included. The reviewed literature offers empirical support for the hypothesis that self-efficacy and effective decision making are related in military contexts.

Favourable results were observed. Numerous studies examining the relationship between self-efficacy and decision making in operational contexts demonstrate the complexity of this phenomenon. Across various methodologies, designs and participant samples, the consensus emerges that self-efficacy is crucial in shaping decision-making effectiveness in high-pressure environments.

The study conducted by Ambrulaitienė[33] with ground force officers in Lithuania highlights the significance of self-efficacy, specifically in tactical leadership planning, in enabling effective decision making in military tasks. Similarly, Boe et al.[35] show that among military cadets, higher self-efficacy predicts increased coping capacity, cooperation in challenging situations, and motivation to achieve, underscoring its critical role in the acquisition of skills, including decision making.

The relationship between emergency dispatchers' self-efficacy and decision-making outcomes was clarified by Cosenzo et al.,[36] who demonstrated that high self-efficacy scores are associated with improved decision-making performance. Findings suggested that those dispatchers with relatively high self-efficacy scores expressed less emotional uncertainty because they felt less nervous about their performance. Moreover, dispatchers who expressed a strong sense of self-efficacy favoured structure, planning and organisation. These dispatchers followed particular procedures in a sequence of steps to determine outcomes to cope with uncertainty, and they typically finished calls faster than those who did not cope. This additional shows that in operational settings, self-efficacy may play a critical role in decision making, mainly because it facilitates stress and uncertainty management.

More information about the relationship between self-efficacy, perseverance and resilience in pilots is provided by Qiu et al.[34] They find that high perseverance levels reinforce the beneficial effects of self-efficacy on resilience, improving pilots' ability to handle special flight situations effectively. Further support for the significance of self-efficacy in aviation contexts comes from Li et al.,[31] who demonstrate that higher levels of self-efficacy are linked to a lower risk of human error among pilots, especially those with less experience. The authors identified that pilots with high levels of one aspect of self-efficacy, flying performance, significantly influence decision making on human error during flight operations. Additionally, work engagement highlights the motivational component of decision-making performance by partially mediating the relationship between human error and self-efficacy.

Lastly, only one study by Lugo et al.[32] suggests relying only a little on instinctive decision making and self-efficacy in complex tasks where counterintuitive problem-solving is needed, like cyber defence. Based on Klein's conceptualisation,[8] their findings highlight the need for a balanced approach to developing decision-making skills by indicating that high levels of self-efficacy and intuitive decision making may impede performance in such contexts.

Considering all the elements, self-efficacy is critical to successful decision making in operational environments. However, its influence depends on several variables, such as task complexity, experience, operational settings and how other psychosocial variables, such as motivation and resilience, interact with it. These findings support Bandura's theory,[20] asserting that people are better at handling complex judgements when they hold a high degree of self-efficacy in their decision-making abilities, which may produce better solutions and more successful results. These findings also align with similar findings in other domains (e.g., sports), suggesting that decision-makers with high levels of self-efficacy make better decisions.[41,42]

Additionally, addressing cultural dimensions is critical when defining self-efficacy, especially across different countries. Hofstede's Power Distance Index (PDI) shows that in hierarchical societies (e.g., China with high PDI), self-efficacy might be the confidence to follow established procedures or fulfil roles within a strict hierarchy. In contrast, in more egalitarian cultures (e.g., Norway or the US with lower PDI), self-efficacy could relate to the ability to pursue personal goals and make independent decisions. This distinction affects how self-efficacy contributes to decision making and leadership in these contexts.[43,44] When applying this concept to military contexts, especially in multinational forces, it's essential to understand that a person's perception of their efficacy may depend on their cultural environment, which shapes how they interact with authority and autonomy.

In concordance with self-efficacy, decision making is also influenced by external factors like available resources. Resources, such as time, tools and training, play a crucial role in shaping decisions, and even the most self-efficacious individuals may struggle if these resources are lacking. In high-resource environments, individuals may feel empowered to make more confident decisions, enhancing self-efficacy, whereas resource-poor settings could hinder decision quality regardless of personal confidence.[43,45]

Understanding how self-efficacy interacts with cultural context and available resources for military organisations can lead to more effective training and leadership development. Military leaders in hierarchical cultures may need to focus on building self-efficacy within procedural compliance, while in egalitarian cultures, they may prioritise fostering autonomy and personal initiative. This understanding allows for better resource allocation and leadership strategies considering internal (self-belief) and external (resources) factors.

Although the reviewed studies provide insightful information, several limitations and directions for future research are noted. Firstly, although validated, various measures were used, making it challenging to combine the results of the studies. Further, comparison, interpretation, and meta-analysis of the studies were hindered due to the relatively small number of available studies. The diverse studies' design and small sample sizes, settings, measures and methodological approaches made the findings hard to interpret, thus impeding the generalizability of the findings. These include the requirement for more targeted populations, which will additionally include more females and diverse demographics, the need for long-term research with follow-ups to demonstrate causal links, and the importance of using standardised measures for self-efficacy and decision making that would allow for easier comparisons of the findings. More longitudinal experiments in naturalistic decision-making environments (such as Cosenzo et al.[36]) in diverse military operational contexts would allow for comparable and valuable insights. Such studies should be replicated and extended to gain a comprehensive understanding of this research area.[46]

In conclusion, findings provide some support for the complex nature of self-efficacy and how it relates to decision making in military populations. More research is necessary to gain a more profound knowledge of the complex relationships between self-efficacy and decision making in various operational contexts to improve mission success and personnel's psychological wellbeing. Finally, this review's conclusions may provide valuable implications for operational decision-making processes, leadership strategies and military training. Understanding the critical role of self-efficacy, military organisations can create interventions that increase personnel's beliefs in their abilities to make decisions under pressure and in a dynamic environment. Techniques to support self-efficacy, like manipulation,[47] that can be included in training programs enclose vicarious learning, social persuasion and opportunities for mastery experiences. Leaders can also foster a supportive environment that encourages personnel to develop their self-efficacy and successfully engage in decision making.

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Murray Valley Encephalitis as 'X' Disease in Australia

G D Shanks, J Aaskov

> *The conclusion is therefore justified that the cases of 'mysterious disease' occurring in Queensland and New South Wales are caused by the same virus as acute poliomyelitis.* Anton Breinl, 1918[1]

Clinical diagnostic technology has steadily improved since the revolutionary advancements in medicine and biology of the 19th Century, led by Louis Pasteur. By the time the SARS-CoV-2 virus emerged in late 2019, causing the COVID-19 pandemic, laboratory testing could confirm and characterise a novel pathogen within hours or days. In the past, identifying new diseases was slower, often leading to speculation about their causes and origins. This article examines a historical case from Australia to explore how emerging diseases transition from sudden crises to recognised public health threats. In most cases, this has avoided ill-informed speculation about the cause of the disease and its origin. We examine a historical example from Australia to understand how newly emerging infectious diseases move from emergency to accepted background threats to human health.

During World War I, a new infectious disease arose in rural Australia. 'Australian X disease' involved the nervous system, was often lethal and there was no apparent means of transmission or effective treatment. Public concern was driven by its similarity to a lethal infection predominating in children, polio, as noted in the initial quote. After two summers, Australian X disease disappeared only to reoccur a few years later.[2,3]

Monkeys injected with neurological tissue from encephalitis patients with Australian X disease by Breinl in Townsville and Cleland et al. in Sydney developed fatal infections.[1,4] Cleland et al. also managed to infect a sheep, a calf and a horse with brain tissue from their monkeys. Breinl believed the agent he had recovered was related to poliovirus. However, Cleland et al. disagreed.[1,4] and when Perdrau re-examined some of the histology sections made by Cleland et al. from the brains of patients with Australian X disease, he noted similarities between these and those from animals infected with Louping Ill virus.[4,5] Louping Ill virus is a tick-

Figure 1: Staff from the Walter and Eliza Hall Institute collecting mosquitoes near the Murray River in Victoria in 1951 during an outbreak of Murray Valley Encephalitis. WEHI photo from https://www.wehi.edu.au/about/history/murray-valley-encephalitis

borne virus primarily affecting cattle and sheep in parts of Europe but it rarely infects humans and is now grouped with the 'encephalitic' flaviviruses to which Murray Valley encephalitis virus belongs.[6] However, Louping Ill virus has never been detected in Australia.

There were two further outbreaks of disease resembling Australian X disease, in 1922 and 1925, but it remains unclear why no further cases were reported between 1925 and 1951.[3] While the 1930s included the Depression, during which occasional deaths due to neurological disease may not have been reported, the medical staff accompanying troops throughout Australia during World War II would have been expected to have noticed cases of Australian X disease in troops for whom they were responsible or in surrounding civilian populations.

It was not until 1951 that a virus was isolated from patients with Australian X disease, and the infection was named Murray Valley encephalitis (MVE). French recovered the virus from three patients by inoculating brain tissue onto the chorioallantoic membrane of eggs.[7] Miles et al. also recovered the virus from a patient by inoculating tissue intracerebrally into day-old mice.[8] While technically easier, this method of virus isolation and performing neutralisation tests required enormous numbers of animals. Doherty's isolation of 24 arboviruses, new to science in the 1960s and 70s, utilised 5–10 000 suckling mice each year.[9]

Serology demonstrated that MVE virus was related to the Japanese B encephalitis virus (now designated Japanese encephalitis) included in the Group B arbovirus family (now flaviviruses). Further characterisation of the new virus had to be performed in the United States because it was not possible to import antisera against viruses that were not known to be circulating in Australia.

The combination of serology and virus recovery from patients should have convinced all observers that the MVE virus was responsible for the recent encephalitis outbreak. However, in 1950, the Australian government released the myxomatosis virus to control/eradicate rabbits that were devastating farmland. This partially successful attempt at biological control had the unfortunate consequence of creating a belief among some in the non-scientific community 'that the myxo had got out' and that the rabbit virus was responsible for MVE. There were anecdotal accounts of tourists passing money for petrol to service station attendants through barely opened car windows to avoid infection with myxomatosis, even though it does not infect humans. Direct human experimentation was used to prove the point and reassure the public. Three of Australia's leading scientists in the 1950s, McFarlane-Burnet from the Walter and Eliza Hall Institute, Fenner from the Australian National University and Clunies-Ross, Chairman of Commonwealth Scientific and Industrial Research Organisation (CSIRO), inoculated themselves with large doses of myxomatosis virus and suffered no ill effects. Richard Casey, the Australian Minister for Science, announced these preliminary results in federal parliament, aiming to reassure the public that MVE was not due to myxomatosis. Fenner later recounted to the senior author that he did not know what they would have done if they had become ill, demonstrating his supreme confidence in his actions without any research committee oversight.[11]

It is unclear what triggered the community alarm about the outbreak of MVE in 1951. Contributing factors may have been that this was a previously unknown virus and the almost concurrent release of myxomatosis virus to control rabbits. Although it had caused no direct effect on human health, the community would have been aware of the debacle surrounding the introduction of cane toads (*Bufu marinus*) to north Queensland in 1935 as a form of biological control of sugar cane beetles.[12]

Since 1951, there have been small numbers of cases of Murray Valley encephalitis reported most years with occasional outbreaks, for example, in 1974 and 2011.[13] Despite its geographically specific name, most MVE cases occur in northern Australia during periods of increased rainfall. The annual average from 2018 to 2023 was three cases (as reported in the National Notifiable Diseases Scheme). There are no commercial tests for the diagnosis of MVE. It is unclear what effect having to refer samples to central state government laboratories has on the testing regime and disease reporting.

MVE has been joined recently (2022) by the closely related Japanese Encephalitis virus (JEV) which has spread south from the Torres Strait into mainland Australia.[14] The rapid spread of Japanese encephalitis cases through eastern Australia and the proximity to pig populations, which are natural hosts of JEV, led to a declaration of a Communicable Disease Incident of National Significance (CDINS).[15] Animal infection studies have suggested that JEV vaccine might provide some cross-protection against infection against MVE and given the public's expectation that new viruses will be matched with new vaccines in less than a year after the success of RNA vaccines during the COVID-19 pandemic, it is worth considering if preparations should be made to employ a JEV vaccine in the face of a serious outbreak of MVE in the future.

The era of fertile eggs and suckling mice for virus isolation has passed and even the cell culture systems that superseded them are less important as an aid to diagnosis than a decade or so ago. The evolving field of metagenomics can identify infectious agents even if we do not know how to grow them in a laboratory setting. This approach is rapid (hours to a day) and provides the genomic information to inform the development of diagnostic tests and vaccines. The next few years will reveal how much improvements in software, like Artificial Intelligence, can make to this process.

Unlike MVE, it will not take 50 years to identify the cause of the subsequent emerging infectious disease due to the improved genomic technology. However, the next disease to emerge in Australia may not be as extensive or life-threatening as COVID-19 and the public health response required may be very different. In the rush to technology, we should not lose sight of the critical role of essential public health interventions.

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Considerations Regarding Appendicitis at Sea

A Garcia, S Beall, D Becerra,

Introduction

When are military providers comfortable providing an 'austere' level of care versus pursuing a higher echelon of care for patients with acute appendicitis? This is a non-issue in active combat scenarios or when medical transport is unavailable. But often, as deployed providers, the decision to treat the patient in a forward, austere location with limited personnel and resources or to medically evacuate (MEDEVAC) them to a more capable care environment is nebulous. The balance when considering the quality of care, risk of transport, cost of transport (including monetary, supplies and personnel) and capability to manage complications makes these decisions complex.

Acute appendicitis is among the most common general surgical diagnoses in the United States (US). Both amphibious warships and aircraft carriers have the capability to perform a laparoscopic appendectomy while at sea, which is the standard of care. That being said, a combination of diagnostic uncertainty, given no afloat cross-sectional imaging and management of potential complications, have given pause to performing these surgeries. There is a need for ongoing discussion regarding the decision making surrounding acute appendicitis at sea.

Case comparison

Two patients presented on a deployed US Navy ship with surgical capabilities. Both patients had abdominal pain, which migrated to the right lower quadrant, normal vital signs and right lower quadrant tenderness to palpation. Symptoms in each case were present for approximately 12 hours prior to workup and diagnosis. No CT is available on the ship, but abdominal ultrasound was attempted in each case without identification of the appendix.

The first patient was a 49-year-old female with a leukocytosis of 19 000. She was evacuated to an American military hospital due to relatively close geographic proximity for further workup and management, where a CT was obtained, confirming the diagnosis of acute appendicitis. The patient underwent an uncomplicated laparoscopic appendectomy the following morning. Due to operational limitations, the patient did not return to the ship for 3 weeks.

The second patient was a 21-year-old male with a leukocytosis of 16 000. He underwent an uncomplicated laparoscopic appendectomy onboard. The patient was given 1 week without duty, followed by return to duty with standard lifting and activity restriction.

Discussion

These cases demonstrate the differential care at sea for similar presentations of the same disease. The following discussion aims to elucidate the major operational and ethical concepts to be considered.

From a military perspective, the goal of deployed medicine is to return the greatest number of service members to their duties by prioritising life, limb and eyesight.[1] This simplified concept becomes more complex when you consider medical personnel's obligation to mimic shore-based standards of care with the available resources. Providers must bias themselves to the best interest of the patient, which may conflict with the operational logistics of a command. With this context, we must weigh the treatment options for acute appendicitis at sea.

Need for cross-sectional imaging

As previously mentioned, the tension between treating a patient at sea versus MEDEVAC ashore is primarily based on the availability of cross-sectional imaging and concern for managing post-operative complications. Both factors directly relate to the lack of cross-sectional imaging on amphibious warships and aircraft carriers, namely computed tomography (CT).

There is evidence that CT appreciably affects surgical management. Rosen et al. noted a surprisingly low 37% concordance between pre- and post-CT diagnosis in patients with a suspected abdominal surgical disease.[2] They reported that CT changed surgical management in 40% of patients, having the greatest impact on patients with suspected appendicitis.[2]

Shaligram et al. studied differential outcomes in patients with suspected appendicitis and found that patients who underwent CT scans experienced significantly lower morbidity, lower ICU admissions and lower readmission rates.[3] The authors further demonstrated that the group most affected were those who did not undergo a CT scan and did not undergo surgical intervention.[8] Separately, Raman et al. showed that increased use of CT was associated with decreased incidence of appendiceal perforation[4].

These data suggest that a critical error occurs when appendicitis is suspected and non-operative management is pursued, leading to an associated delay in definitive management and increased morbidity. While it seems obvious that CT improves the care of patients with suspected appendicitis, it is not the current reality of care at sea.

Antibiotics versus surgery for acute uncomplicated appendicitis

The 'antibiotics versus surgery for acute appendicitis' is a conversation that frequently occurs in shipboard medical departments and deserves mention. There is often a perception that operative management carries an inherently higher risk than antibiotic treatment. The thought is that risk can be mitigated by electing for antibiotic treatment, which is supported as a primary treatment for appendicitis in the literature. What is important to note is that in studies directly comparing antibiotics to surgery for acute appendicitis, the antibiotic group experienced treatment failure requiring operative management in 29% of patients at 90 days, 40% at 1 year, and 49% at 3 years.[5,6] Alarmingly, when patients in the antibiotics group recurred, perforation was reported in 20% of patients.[6] Given the already noted lack of cross-sectional imaging or interventional radiology capabilities, the high rate of failure with antibiotics alone and associated morbid complications, specifically abscess formation and sepsis without access to reliable percutaneous drainage, carry a greater risk than surgery at sea.[7]

Logistical considerations

Based on the data presented, the most appropriate option is appendectomy versus MEDEVAC for a shore-based diagnostic workup and probable surgery. Assuming the risk of surgery is the same for the patient at sea and ashore, the risks associated with the MEDEVAC process must be addressed and considered. Notably, performing an uncomplicated surgery at sea returns the service member to their duties the quickest (3 weeks sooner in this case comparison). However, that should not necessarily be the provider's foremost concern ethically. The MEDEVAC process involves maritime air transport and the finite resources of fuel, aircraft repairs, aircraft maintenance and the low but present risk of an aviation mishap at sea.[8] Ship diversion for aircraft range also represents a difficult-to-quantify cost. In many cases, the patients are transported multiple times in the MEDEVAC process, adding both cost and risk.[8] In addition to the obvious material and personnel considerations in the MEDEVAC operation, a patient with acute appendicitis could quickly deteriorate during this process without access to a physician, much less surgical capabilities. All these described costs and risks are difficult to quantify in bulk for direct comparison to afloat medical care.

Command discussion

The recommendation for operative management must be approved by both medical and line commanding officers. It should be communicated that appendectomy carries a complication rate of about 5% for uncomplicated appendicitis and up to 25% for perforated appendicitis.[9] The treatment and logistical options should be communicated in terms of risk to the patient, specifically noting that increased time to treatment contributes to a greater risk of perforation and complications[9]. Additionally, risk profiles should include not only initial treatment risk (surgery vs MEDEVAC vs antibiotics), but also latent risk (surgical complications and risk of treatment failure). It cannot be overstated that the patient's best interest of the patient, agnostic to any perceived risk to the command, should always be at the forefront of the discussion.

Final thoughts

Military medical providers working in austere environments will always be required to make clinical decisions without the standard medications, technology- personnel compared to shore-based facilities. Service members understand and implicitly accept that equal care to US based hospitals is not always possible. This back and forth between the ideal care scenario, what is available on the ship, and what is available through the MEDEVAC process is not a clear-cut concept.

The expected yet disappointing answer is that there is not an obvious solution. The data suggests that a lower threshold for operative management in an austere environment, will lead to better patient outcomes versus treating with antibiotics alone. One could argue that MEDEVAC to a medical facility meeting home port standard of care with CT capability and the ability to manage potential complications with interventional radiology is equally reasonable. The decision to operate at sea versus MEDEVAC is complex. However, if a MEDEVAC is easily attainable to a care facility equivalent to the shore-based standard of care for the service member, then MEDEVAC is a reasonable alternative to ship-based surgical care. Discussion between multiple providers is essential to formulating an appropriate plan that is in the patient's best interest regardless of the operational environment.

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Notes

Notes

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